

Synthesis of Marine Ecosystem Monitoring Activities for the United States Virgin Islands: 1990-2009



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Photographs provided by NOAA staff.

Synthesis of Marine Ecosystem Monitoring Activities for the United States Virgin Islands: 1990-2009

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NOAA Technical Memorandum NOS NCCOS 148

About this document

This report provides a synthesis of marine monitoring activities that have taken place in the nearshore waters of the U.S. Virgin Islands between 1990 and the end of 2009. Summary metadata are provided that describe the monitoring programs, their implementing agency, the ecosystem components that are measured together with maps showing where the measurements were taken. This information is intended to facilitate data sharing and synergies between monitoring programs, inform and enhance strategic planning for regional and national monitoring, avoid duplication of effort and increase knowledge and awareness of the spatial, temporal and compositional characteristics of monitoring in the U.S. Virgin Islands.

The information was compiled as a contribution to the Comprehensive Caribbean Coral Reef Ecosystem Monitoring Project (C-CCREMP) project funded by NOAA Coral Reef Conservation Program.

For more information on C-CCREMP and related projects please visit NCCOS' webpage (<http://ccma.nos.noaa.gov/ecosystems/coralreef/ccremf/>) or direct questions and comments to:

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Table of Contents

Executive Summary

1. Background

2. Purpose of C-CCREMP

3. Definition of Monitoring and Surveillance Surveys

4. What is Monitored, When, Where and by Whom?

4.1 Biological Variables

4.1.1 Queen Conch (*Eustrombus gigas*)

4.1.2 Spiny lobster (*Panulirus argus* & *P. guttatus*)

4.1.3 Fish Communities & Fish Movements

4.1.4 Benthic Community Composition (inc. Coral & Seagrasses)

4.1.5 Corals

4.1.6 Acropora spp.

4.1.7 Seagrasses

4.1.8 Ciguatera

4.2 Physical and Oceanographic Variables

4.2.1 Water Quality

4.2.2 Sediment

4.2.3 Oceanographic

5. Monitoring Activities by Management Units

5.1 St. Thomas & St. John

5.2 St. John

6. Gap Analysis

6.1 Spatial Gaps

6.2 Temporal Gaps

6.3 Parameter Gaps

7. Recommendations

Appendices

- I. Posters of historical and ongoing sampling effort around St. Thomas and St. John
- II. Posters of historical and ongoing sampling effort around St. Croix
- III. Table of satellite remote sensing data for marine monitoring at broader spatial scales

1. Background

The ecological integrity of coral reef ecosystems in the U.S. Caribbean is widely considered to have deteriorated in the last three decades due to a range of threats and stressors from both human and non-human processes (Rothenberger 2008, Wilkinson 2008). In response to the threats to Caribbean coral reef ecosystems and other regions around the world, the United States Government authorized the Coral Reef Conservation Act of 2000 to: (1) preserve, sustain, and restore the condition of coral reef ecosystems; (2) promote the wise management and sustainable use of coral reef ecosystems to benefit local communities and the Nation; and (3) develop sound scientific information on the condition of coral reef ecosystems and the threats to such ecosystems. The Act also resulted in the formation of a National Coral Reef Action Strategy and a Coral Reef Conservation Program.

The Action Strategy (Goal 2 of Action Theme 1) outlined the importance of monitoring and assessing coral reef health as a mechanism toward reducing many threats to these ecosystems. Monitoring was considered of high importance in addressing impacts from climate change; disease; overfishing; destructive fishing practices; habitat destruction; invasive species; coastal development; coastal pollution; sedimentation/runoff and overuse from tourism. The strategy states that successful coral reef ecosystem conservation requires adaptive management that responds quickly to changing environmental conditions. This, in turn, depends on monitoring programs that track trends in coral reef ecosystem health and reveal patterns in their condition before irreparable harm occurs. As such, monitoring plays a vital role in guiding and supporting the establishment of complex or potentially controversial management strategies such as no-take ecological reserves, fishing gear restrictions, or habitat restoration, by documenting the impacts of gaps in existing management schemes and illustrating the effectiveness of new measures over time. Long-term monitoring is also required to determine the effectiveness of various management strategies to conserve and enhance coral reef ecosystems.

Furthermore, it is widely believed that a rigorous monitoring and assessment program will contribute to and improve coral reef conservation efforts by:

- Documenting the status of ecologically and economically important reef species.
- Assessing and tracking changes in reef communities in response to environmental stressors or specific human activities and uses.
- Evaluating the effectiveness of specific management strategies and identify actions for future adaptive responses.
- Evaluating the natural recovery and/or restoration of injured or degraded reefs.
- Enabling informed decisions about the location of potentially harmful activities by providing baseline data on community composition and predicted ecosystem response.

- Providing baselines for assessing catastrophic damage from natural or anthropogenic events such as storms, diseases, climate change, coral bleaching, vessel groundings, and toxic spills.
- Serving as an early warning system for identifying declines in coral reef ecosystem health.

In recent years, the monitoring of coral reef ecosystems in the U.S. Caribbean has become an important component of marine management. Integration of strategic applied science and monitoring and assessment provide the information needed to support effective management and the evidence to inform managers and the broader community of ecosystem status and change. Consequently, the monitoring has become a significant component of NOAA's Coral Reef Conservation Program through the Coral Reef Ecosystem Integrated Observing System (CREIOS). CREIOS monitoring includes biological, physical, and chemical components: direct, periodic field observations of the condition of coral reef ecosystems, and automated, continuous monitoring of key environmental factors that are known to affect their condition (Figure 1). CREIOS activities include periodically repeated measurements on time scales that range from continuous (using *in situ* instrument arrays) to biennial (monitoring cruises using NOAA ships). Remote sensing from space-borne satellites also provides monitoring data, although these data are rarely used for monitoring of nearshore marine environments in the U.S. Virgin Islands.

Reviews and needs assessments of monitoring activities in the U.S. Caribbean have highlighted the challenge for coordinated monitoring and revealed that monitoring is carried out by multiple agencies to meet different management objectives, using highly variable and sometimes limited resources and often applying a wide range of sampling strategies and data collection techniques. This impedes data integration and synthesis and typically results in a spatially and temporally disjointed perspective on ecosystem health. In addition, it is thought that relatively little flow of information takes place between agencies that implement monitoring programs in the region. Major reviews of monitoring for coral reef ecosystems in the U.S. Caribbean have included:

NOAA C-CCREMP Workshops, St. Thomas, USVI, 2006

http://ccma.nos.noaa.gov/ecosystems/coralreef/ccremp/CCREMPReport_020707.pdf

EPA Coral Reef Monitoring Needs Assessment Workshop, St. Croix, USVI, 2008

NOAA CREIOS Workshop, Puerto Rico, 2009

<http://coralreef.noaa.gov/aboutcrp/strategy/reprioritization/creios/#atlantic>

National Park Service Vital Signs Monitoring, 2009

<http://science.nature.nps.gov/im/monitor/index.cfm>

2. Purpose of C-CCREMP

To facilitate efficient use of available monitoring data and to support strategic decision making for future monitoring, a comprehensive synthesis of existing monitoring activities was carried out by the Comprehensive Caribbean Coral Reef Ecosystem Monitoring Project ([C-CCREMP](#)). This project compiled summary information on marine monitoring activities in the U.S. Caribbean and made this information available through an online mapserver and synthesis report. The purpose of this project was not to replace or dramatically change current monitoring efforts, but rather to develop an integrated system for monitoring coral reef health to support both territorial and Federal partners. It was predicated on the view that by sharing information more broadly, agencies can modify and integrate current monitoring programs to improve the efficiency and effectiveness of assessments of coral reef resources. One desired outcome was to examine the potential for an expansion of existing U.S. Caribbean coral reef ecosystem monitoring studies into a comprehensive long-term monitoring and assessment program. A comprehensive monitoring program would provide consistent, reliable information that can be used for cross-jurisdictional comparison of coral reef ecosystem conditions.

As part of the C-CCREMP, NCCOS Biogeography Branch of the Center for Coastal Monitoring & Assessment and NMFS-Galveston Laboratory developed a web-based system for compiling metadata on recent and current monitoring and assessment activities. Scientists and managers submitted information about projects, and FGDC-compliant metadata files were created by C-CCREMP staff.

C-CCREMP was funded by the Coral Reef Conservation Program and consisted of a partnership project between territorial and Federal resource managers and scientists led by three NOAA programs; the NOS Coral Reef Conservation Program (CRCP), NOS Center for Coastal Monitoring and Assessment (CCMA) and the NMFS Southeast Fisheries Science Center. Partners involved included National Park Service, Department of Planning and Natural Resources of the Virgin Islands Government, the University of the Virgin Islands, the Puerto Rico Department of the Natural Environment and Resources, the U.S. Geological Survey and the Environmental Protection Agency and several others.

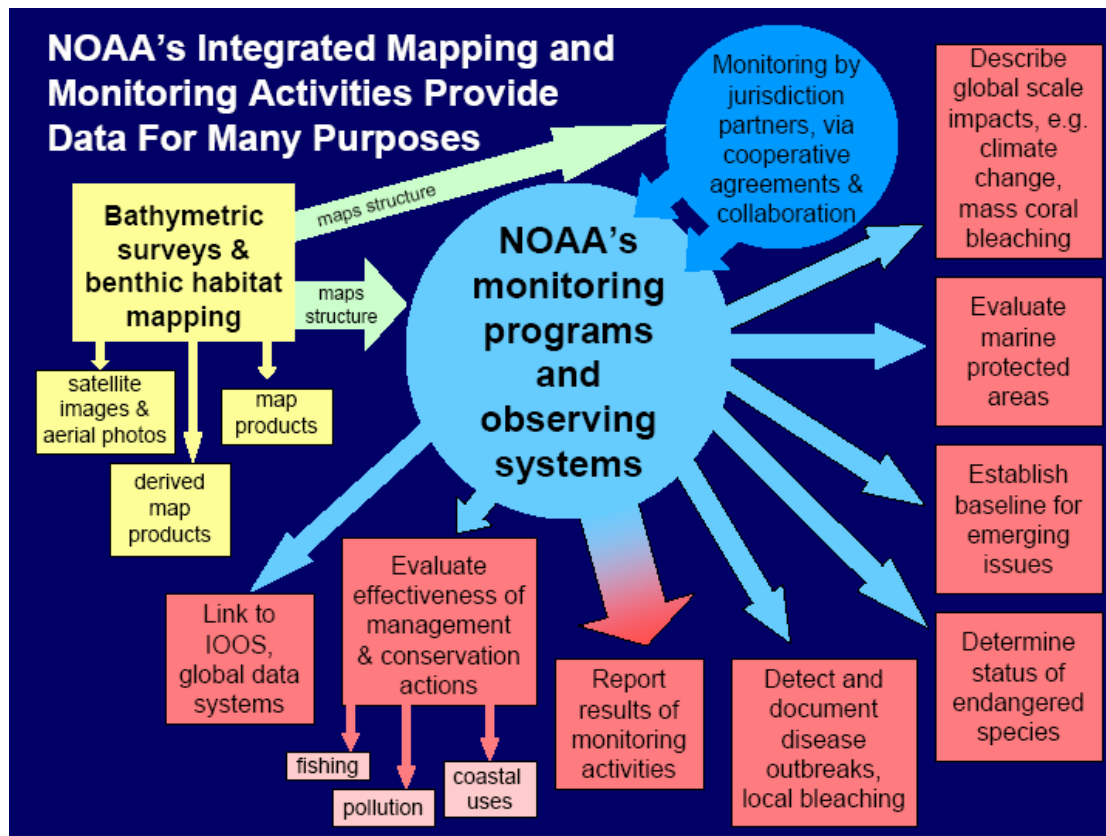


Figure 1. NOAA's mapping and monitoring services are interlinked across many projects, programs and Line Offices and provide data for many purposes.

3. Definition of monitoring

The data collected for C-CCREMP included samples that were collected for the purpose of *surveillance* and for *monitoring*. For this report we define *surveillance* as a continued program of biological surveys systematically undertaken to provide a series of observations in time and space. *Monitoring* is surveillance undertaken to ensure that formulated standards are being maintained. Therefore, monitoring provides the information to compare actual status at the time of recording with a target value (i.e. total maximum daily loads), to enable an assessment of whether or not the parameter or feature of interest is in favorable condition. This information can feed into an adaptive management system, a structured, iterative process of optimal decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring (Figure 2). We also included here acoustic tracking projects as a type of surveillance data because the data provide a time series of biological activity that is referenced in time and space. For strategic purposes, we also include programs that are currently undertaking scientific surveillance, but that have potential to become monitoring programs in the future (e.g., ciguatera studies).

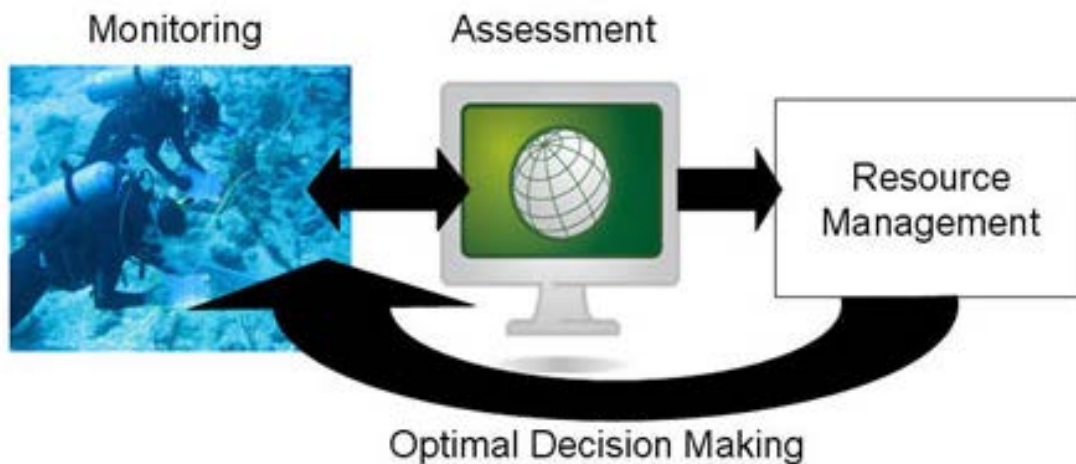
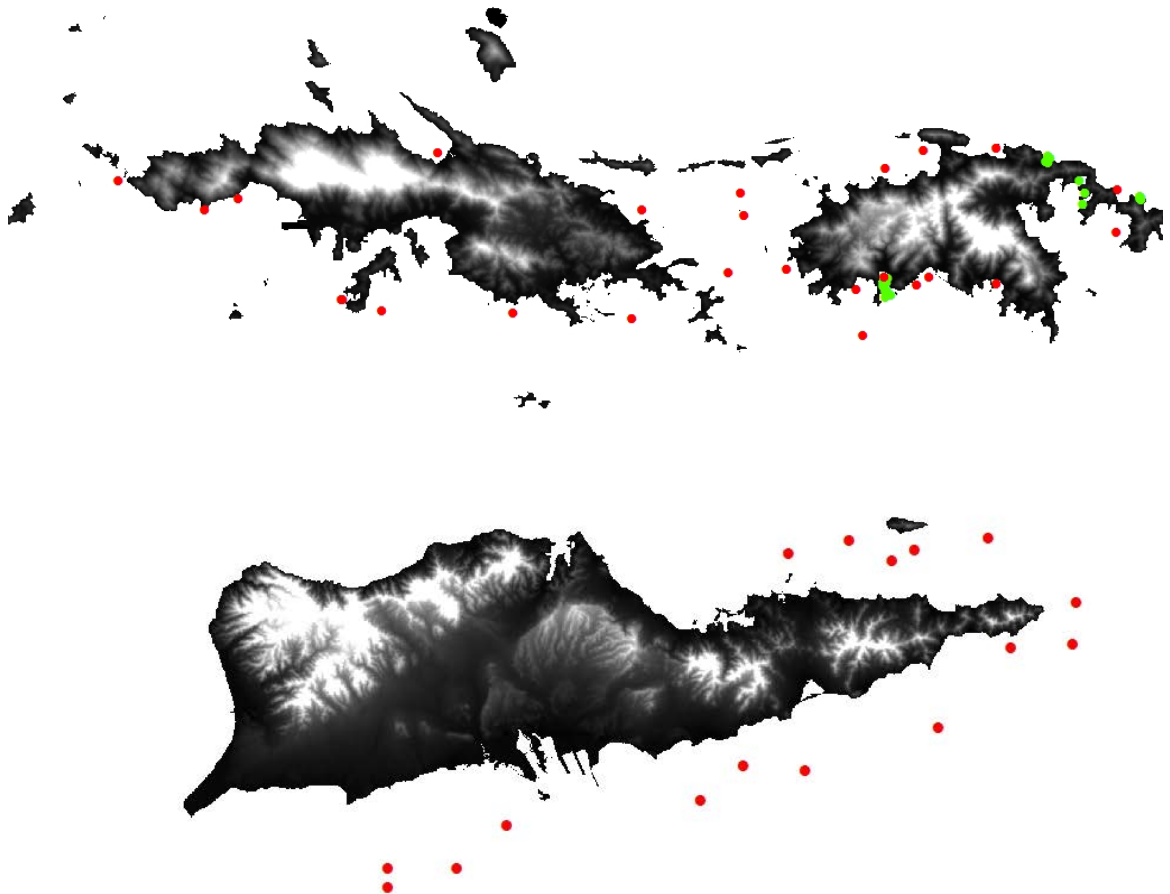
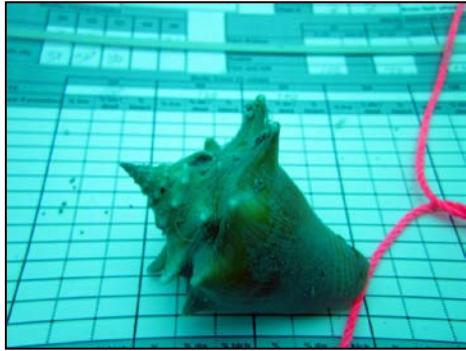


Figure 2. Monitoring has a core role in the adaptive management framework.

4.1 Biological Variables

4.1.1 Queen Conch (*Eustrombus gigas*)



Monitoring Programs

- ! DPNR SEAMAP
- ! NOAA Fisheries

0 5 KM

Virgin Islands Department of Planning & Natural Resources/NMFS-SEAMAP

Purpose: To determine the status of conch stocks, assess the effectiveness of management regulations and make management suggestions. The Southeast Area Monitoring and Assessment Program (SEAMAP) is a State/Federal program designed to collect, manage and disseminate fishery-independent data in the southeastern U.S. including the U.S. Caribbean. Results from 2001 were compared with previous surveys in 1981, 1985, 1990 and 1996. NOAA funding.

Project Dates: 1998 - 2001

Variables Measured: Abundance, density, length, lip thickness, habitat

Location(s): St. Thomas, St. John, St. Croix

Measurement Frequency: Irregular (1981, 1985, 1990, 1996)

Project Webpage: <http://sero.nmfs.noaa.gov/grants/seamap.htm>

Contacts: Shennell Gordon shenellgordon@yahoo.com

Relevant publication: Tobias, W. 2005. Assessment of Conch Densities in Backreef Embayments on the northeast and southeast coast of St. Croix, U.S. Virgin Islands. Department of Planning & Natural Resources. [Report](#) to: Southeast Area Monitoring and Assessment Program – Caribbean (SEAMAP-C).

NOAA Fisheries Southeast Fisheries Science Center (SEFSC)

Purpose: To examine the population status, growth, mortality, and migration rates of juvenile and adult conch in two bays bordering the Virgin Islands National Park on St. John, Fish and No Name (Saba) Bays. NOAA funding.

Project Dates: 2005-2009

Variables measured: Conch movements using acoustic receivers

Location(s): St. John

Measurement Frequency: Tri-annually

Project Webpage:

<http://galveston.ssp.nmfs.gov/research/fisheryecology/currentresearch/QueenConch/index.html>

Contacts: Ron Hill ron.hill@noaa.gov

NOAA/NCCOS/CCMA Biogeography Branch Coral Reef Ecosystem Monitoring Project

Purpose: To spatially characterize and monitor the distribution, abundance, and size of reef fishes and macro-invertebrates; to use this information to establish the knowledge base necessary for enacting management decisions in a spatial setting; to establish the efficacy of those management decisions; and to work with the National Coral Reef Monitoring Program to develop data collection standards and easily implemented methodologies. At each randomly located survey site, abundance and maturity of queen conch are quantified within a 25 m x 4 m belt transect. Funded by National Park Service and NOAA Coral Reef Conservation Program.

Project Dates: 2001- ongoing

Variables measured: Conch size and abundance

Location(s): St. John & St. Croix

Measurement Frequency: Biannually for St. Croix; Annually for St. John

Project Webpage:

http://www.ccma.nos.noaa.gov/ecosystems/coralreef/reef_fish/

Contacts: Chris Caldwell chris.caldow@noaa.gov

Relevant publication: Pittman SJ, Hile SD, Jeffrey CFG, Caldwell C, Kendall MS, Monaco ME, Hillis-Starr Z (2008) [Fish assemblages and benthic habitats of Buck Island Reef National Monument \(St. Croix, US Virgin Islands\) and the surrounding seascape: A characterization of spatial and temporal patterns. NOAA Technical Memorandum 71.](#)

National Park Service Conch Monitoring

Purpose: To assess the status of conch populations and compare changes in density across surveys conducted since 1981 to measure the effects of management regulations.

Project Dates: 1990 and 1996

Variables measured: Conch length, maturity, abundance, habitat type

Location(s): St. John and St. Thomas

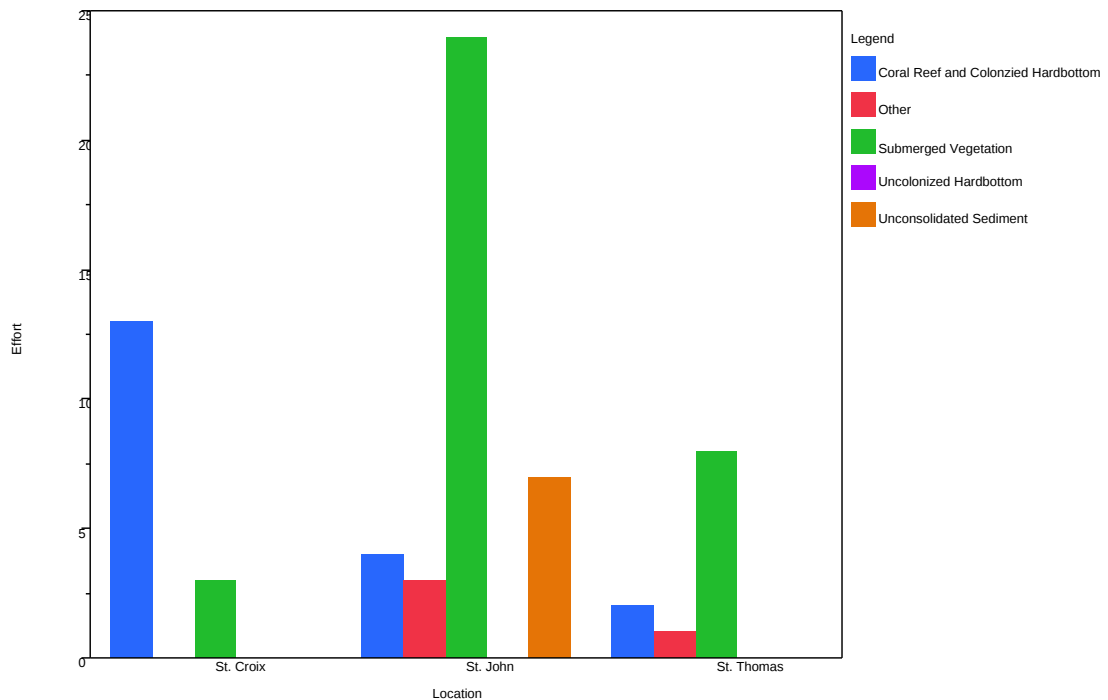
Measurement Frequency: Infrequent

Project Webpage: Not available

Contacts: [Rafe Boulon@nps.gov](mailto:Rafe_Boulon@nps.gov) or

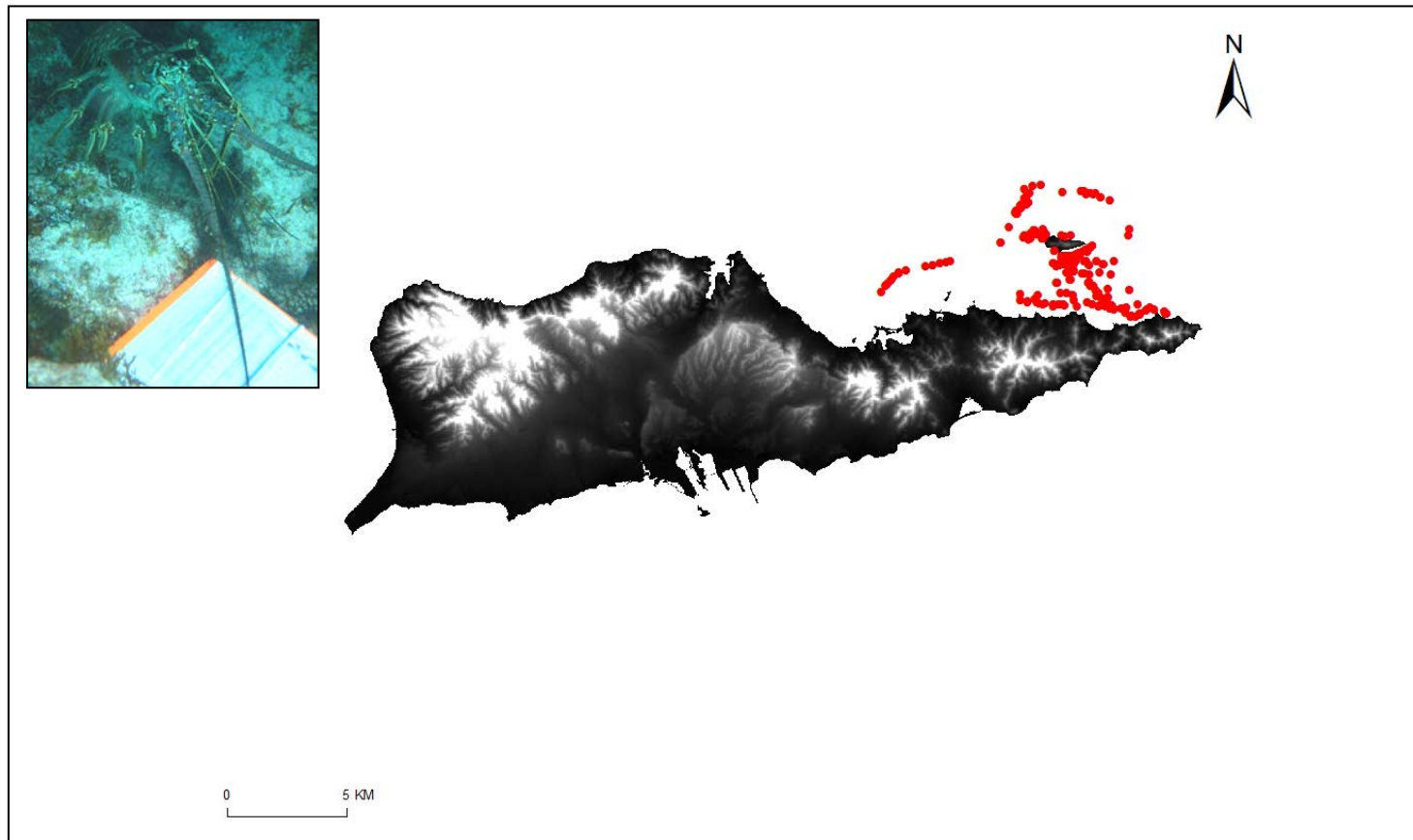
Alan Friedlander alan_friedlander@usgs.gov

Relevant publication: Friedlander, AM (1997) Status of queen conch populations around the northern US Virgin Islands with management recommendations for Virgin Islands National Park. Biological Resources Division. United States Geological Survey. Virgin Islands NP Field Station, St. John, USVI. 39 pp.



Graph 1. Number of georeferenced Queen conch survey sites (effort) by island and habitat type in the U.S. Virgin Islands (1990-2009). NB: NPS surveys not included as exact geolocations locations were not known.

4.1.2 Spiny Lobster (*Panulirus* spp.)



National Park Service (NPS) and Florida Fish & Wildlife Conservation Commission (FWC)

Purpose: To assess the size and status of lobster populations in Buck Island Coral Reef National Monument (BIRNM) and neighboring areas and to determine the effectiveness of the BIRNM reserve for spiny lobster populations. Assess suitable lobster habitat and develop monitoring protocol for NPS. Conducted through collaboration with Florida Fish & Wildlife Conservation Commission.

Project Dates: 2004 - 2007 completed

Variables Measured: Species, relative abundance, body size

Location(s): Buck Island Reef National Monument and NE St. Croix

Measurement Frequency: Annually

Project Webpage: Not available

Contacts: Zandy Hillis-Starr NPS or Carrollyn Cox FWC

carrollyn.cox@fwc.state.fl.us

Relevant publication: Trip reports available on request from National Park Service, BIRNM.

NOAA/NCCOS/CCMA Biogeography Branch Coral Reef Ecosystem Monitoring Project

Purpose: To spatially characterize and monitor the distribution, abundance, and size of fishes and macro-invertebrates; to use this information to establish the knowledge base necessary for enacting management decisions in a spatial setting; to establish the efficacy of those management decisions; and to work with the National Coral Reef Monitoring Program to develop data collection standards and easily implemented methodologies. At each randomly located survey site, abundance of spiny lobster are quantified within a 25 m x 4 m belt transect.

Project Dates: 2001 – ongoing

Variables measured: Abundance

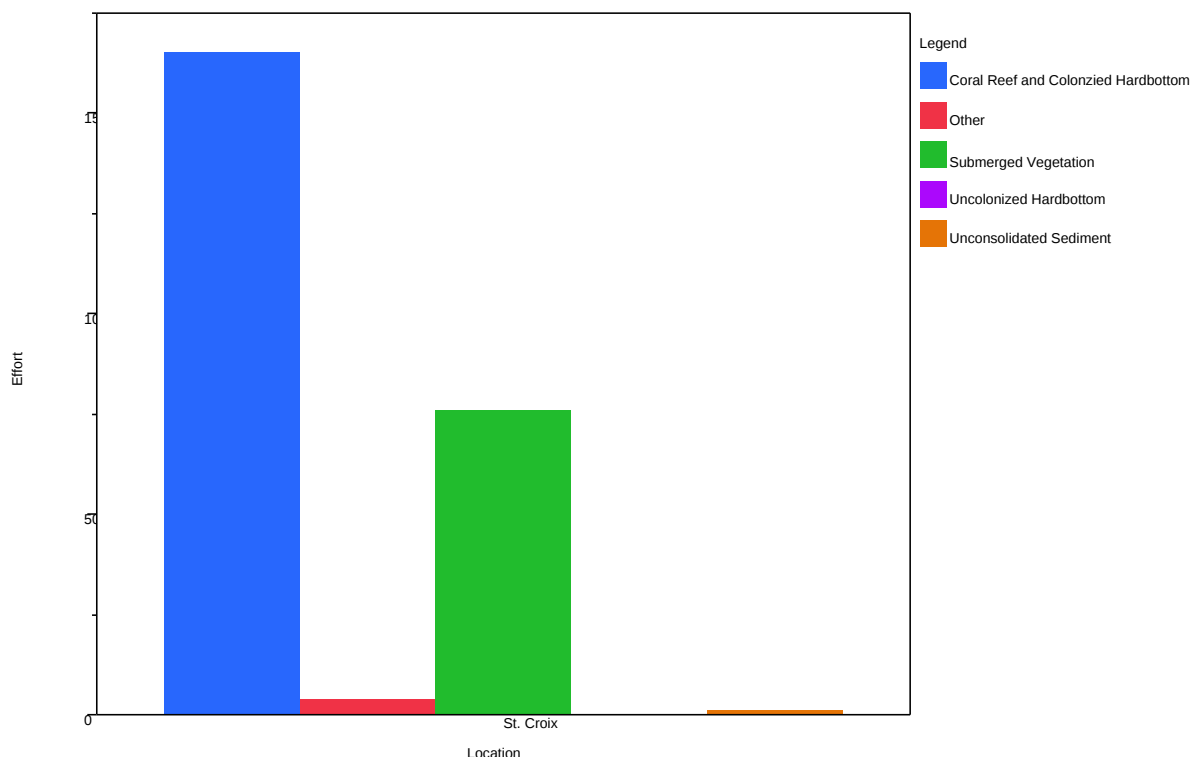
Location(s): St. John & St. Croix

Measurement Frequency: Biannually for St. Croix; Annually for St. John

Project Webpage: http://www.ccma.nos.noaa.gov/ecosystems/coralreef/reef_fish/

Contacts: Chris Caldwell chris.caldow@noaa.gov

Relevant publication: Pittman SJ, Hile SD, Jeffrey CFG, Caldwell C, Kendall MS, Monaco ME, Hillis-Starr Z (2008) [Fish assemblages and benthic habitats of Buck Island Reef National Monument \(St. Croix, US Virgin Islands\) and the surrounding seascape: A characterization of spatial and temporal patterns. NOAA Technical Memorandum 71.](#)



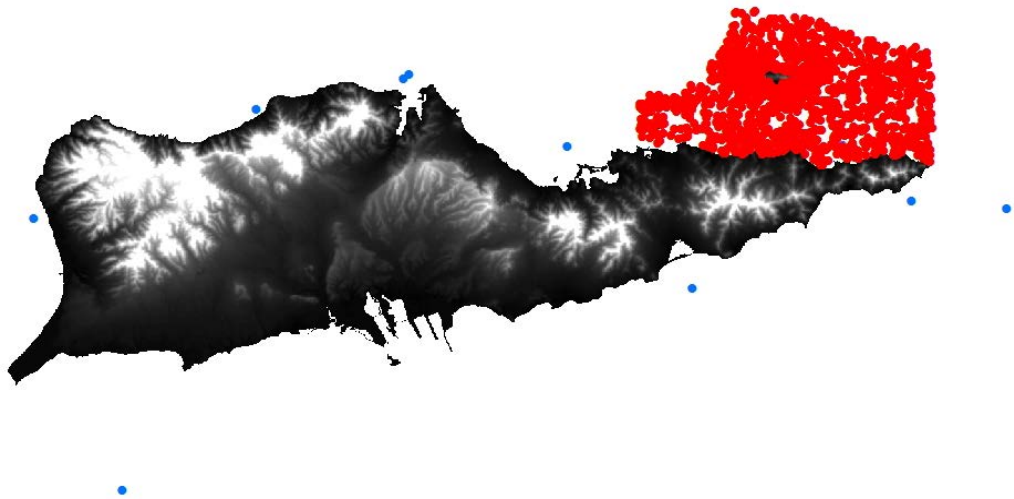
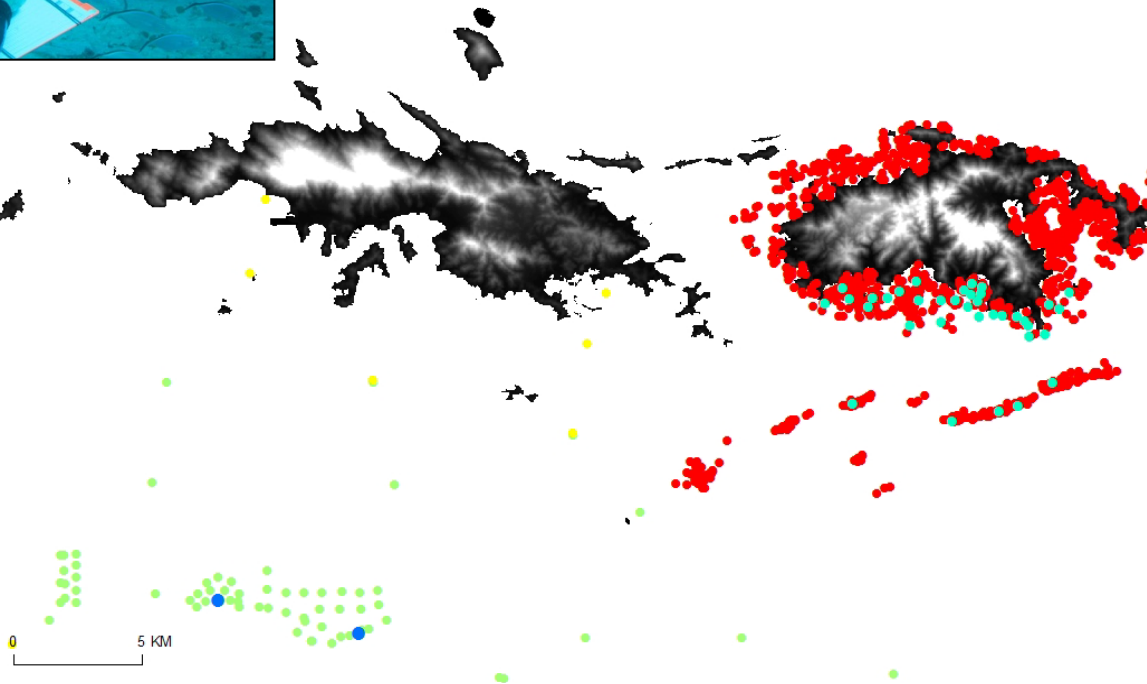
Graph 2. Number of georeferenced spiny lobster survey sites (effort) by island and habitat type in the U.S. Virgin Islands (1990-2009).

4.1.3 Fish Communities & Fish Movements



Monitoring Programs

- NOAA CCMA Receivers
- UVI CMES Receivers
- CRMP CMES SPAG
- NOAA Biogeography Branch
- CRMP CMES FISH



Monitoring Programs

- NOAA Biogeography Branch
- CRMP CMES Fish

USVI Territorial Coral Reef Monitoring Program (TCRMP CMES Fish Surveys)

Purpose: The goal of the territorial coral reef monitoring program is to provide long-term trend data on territorial coral reef condition. Monitoring fish populations, with special attention to fished species, as commissioned by Virgin Islands Department of Planning and Natural Resources (DPNR). Funded by Coral Reef Conservation Program Monitoring Grants.

Project Dates: St. Croix 2001- ongoing; St. Thomas 2003 - ongoing

Variables Measured: Fish species, size and abundance

Location(s): St. Thomas, St. Croix

Monitoring Frequency: Annually

Project Webpage:

http://www.uvi.edu/sites/uvi/Documents/Research%20and%20Public%20Service/CMES/uvi_cmes_tcrmp_description.pdf

Contacts: Tyler Smith tsmith@uvi.edu

UVI-CMES Spawning Aggregations (SPAG)

Purpose: To monitor fish populations at spawning aggregations.

Project Dates: 1999- ongoing

Variables Measured: Fish density, size distribution and temporal dynamics of spawning aggregations

Location(s): St. Thomas, St. Croix

Measurement Frequency: Annually

Project Webpage: Not available

Contacts: Rick Nemeth rnemeth@uvi.edu

Relevant Publication: Nemeth R.S. 2005. [Population characteristics of a recovering US Virgin Islands red hind spawning aggregation following protection. Marine Ecology Progress Series 286:81-97.](#)

NOAA/NCCOS/CCMA Biogeography Branch Coral Reef Ecosystem Monitoring Project

Purpose: To spatially characterize and monitor the distribution, abundance, and size of fishes and macro-invertebrates; to use this information to establish the knowledge base necessary for enacting management decisions in a spatial setting; to establish the efficacy of those management decisions; and to work with the National Coral Reef Monitoring Program to develop data collection standards and easily implemented methodologies. At each randomly located survey site, abundance and size of fish are quantified within a 25 m x 4 m belt transect.

Project Dates: 2001 - ongoing

Variables Measured: Fish abundance, fork length, species richness, biomass

Location(s): St. John, St. Croix

Measurement Frequency: Bi-annually

Project Webpage:

http://www.ccma.nos.noaa.gov/ecosystems/coralreef/reef_fish/

Contacts: Chris Caldwell chris.caldow@noaa.gov

Relevant Publication: Monaco M.E., Friedlander A.M., Caldwell C., Hile S.D., Menza C. and R.H. Boulon. 2009. [Long-term monitoring of habitats and reef fish](#)

[found inside and outside of the US Virgin Islands Coral Reef National Monument: a comparative assessment](#). Caribbean Journal of Science. 45:338-347.

NOAA/NCCOS/CCMA Biogeography Branch Fish Tracking

Purpose: Examine the movement of fish species, among different trophic guilds and possessing a range of life history characteristics, inside and outside Virgin Islands National Park; examine the movement of fish species, among different trophic guilds and possessing a range of life history characteristics, between inshore habitats within VIIS and offshore habitats within the VICR; examine the habitat utilization patterns and movements of fishes over diel time periods at small and large spatial scales; and examine the habitat utilization patterns and movements of fishes over time periods ranging from weeks to months to years.

Project Dates: 2006-2009

Variables Measured: Timing of fish movements via acoustic receivers

Location(s): St. John

Measurement Frequency: Continuous

Project Webpage:

http://ccma.nos.noaa.gov/ecosystems/coralreef/acoustic_tracking/

Contacts: Chris Caldwell chris.caldow@noaa.gov

Relevant Publication: Friedlander, A.M. and M.E. Monaco. 2007. [Acoustic Tracking of Reef Fishes to Elucidate Habitat Utilization Patterns and Residence Times Inside and Outside Marine Protected Areas Around the Island of St. John, USVI](#). NOAA Technical Memorandum NOS NCCOS 63, Silver Spring, MD. 50p.

University of the Virgin Islands, CMES, Tracking of Aggregating Fish Species

Purpose: Tracking movements of acoustically tagged fish (snappers, groupers, sharks) at spawning aggregations and between spawning aggregations and nearshore environments.

Project Dates: 2006 - ongoing

Variables Measured: Fish movements via acoustic receivers

Location(s): St. Thomas, St. John

Measurement Frequency: Continuous

Project Webpage: Not available

Contacts: Rick Nemeth rnemeth@uvi.edu

Relevant Publication: Nemeth, R.S., Blondeau J., Herzlieb S., Kadison E. 2007. [Spatial and temporal patterns of movement and migration at spawning aggregations of red hind, *Epinephelus guttatus*, in the U.S. Virgin Islands. Environmental Biology of Fishes 78:365-381.](#)

National Park Service Long Term Monitoring of Fish Assemblages

Purpose: To establish a baseline of information on reef fish assemblages around St. John; conduct sustained monitoring on representative high-diversity reefs; collect data on reefs with known or potential environmental degradation; compare fish assemblages among selected reefs and determine trends in reef fish assemblages over time. From 1988 to 1994 18 sites were monitored annually using underwater visual census and from 1995 onward four established reference sites were monitored (see maps below from Friedlander & Beets 2008).

Project Dates: 1988 - ongoing

Variables Measured: Fish abundance and body size

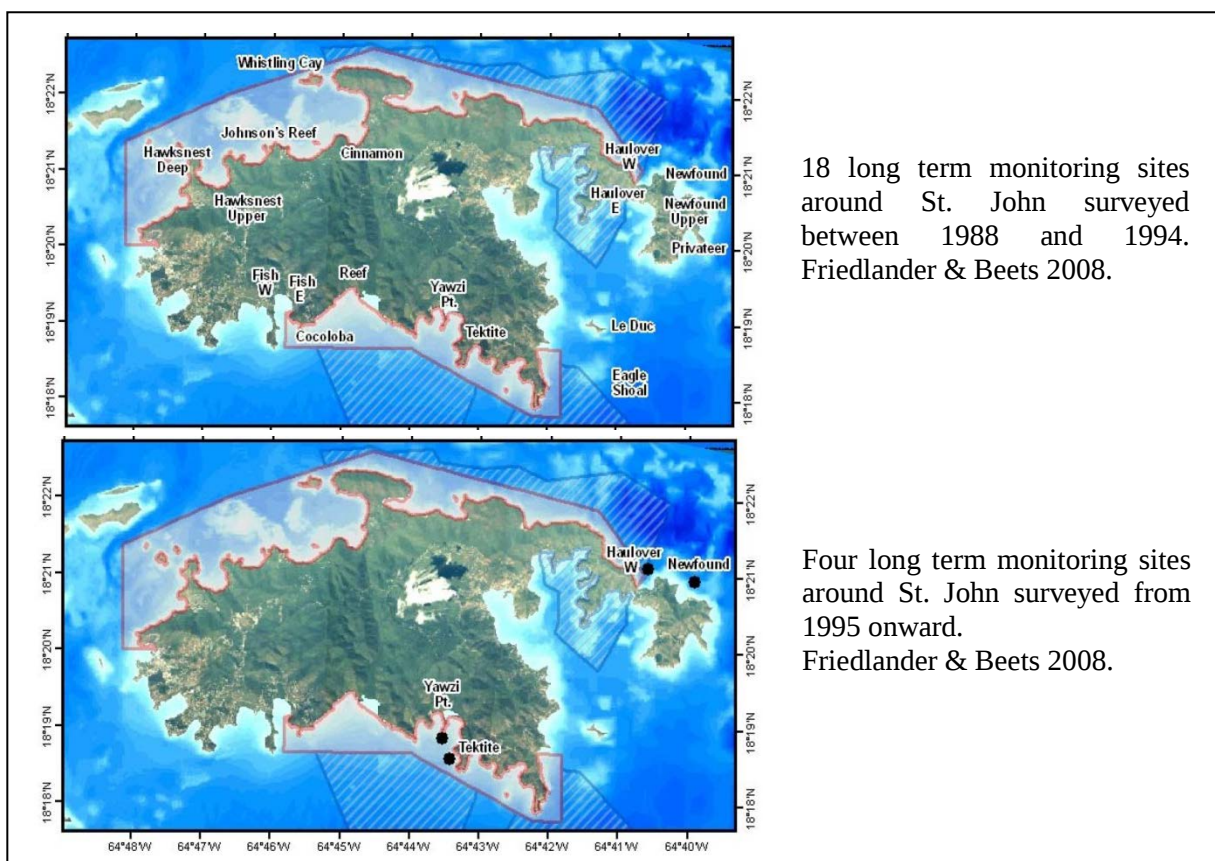
Location(s): St. John

Measurement Frequency: Annually

Project Webpage: Not available

Contacts: Alan Friedlander friedlan@hawaii.edu or Jeff Miller William_J_Miller@nps.gov

Relevant Publication: Friedlander, A.M., and J. Beets. 2008. [Temporal Trends in Reef Fish Assemblages inside Virgin Islands National Park and around St. John, U.S. Virgin Islands, 1988-2006. Biogeography Branch, Silver Spring, MD. NOAA Technical Memorandum NOS NCCOS 70. 60 pp.](#)



18 long term monitoring sites around St. John surveyed between 1988 and 1994. Friedlander & Beets 2008.

Four long term monitoring sites around St. John surveyed from 1995 onward. Friedlander & Beets 2008.

VI Government, DPNR, Division of Fish & Wildlife Fish Aggregating Devices

Purpose: To monitor the use of fish aggregating devices around the Virgin Islands. The Division of Fish and Wildlife has deployed fish aggregating devices (FADs). The surface FADs consist of a 58" diameter steel sphere surface buoy with a radar reflector and strobe light. Submerged FADs consist of 1 or 2 metal canisters at least 50 ft below the surface.

Project Dates:

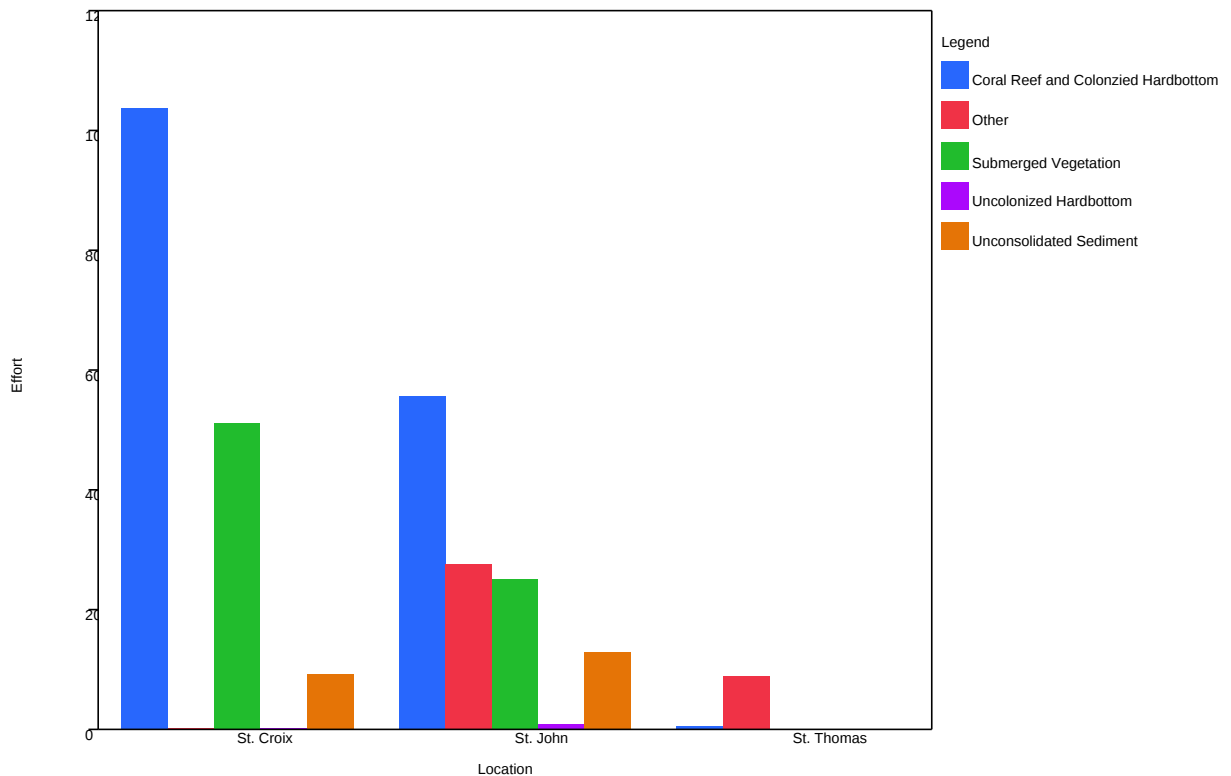
Variables Measured: Fish species, abundance and body size

Location(s): St. Thomas & St. Croix

Measurement Frequency: Annually

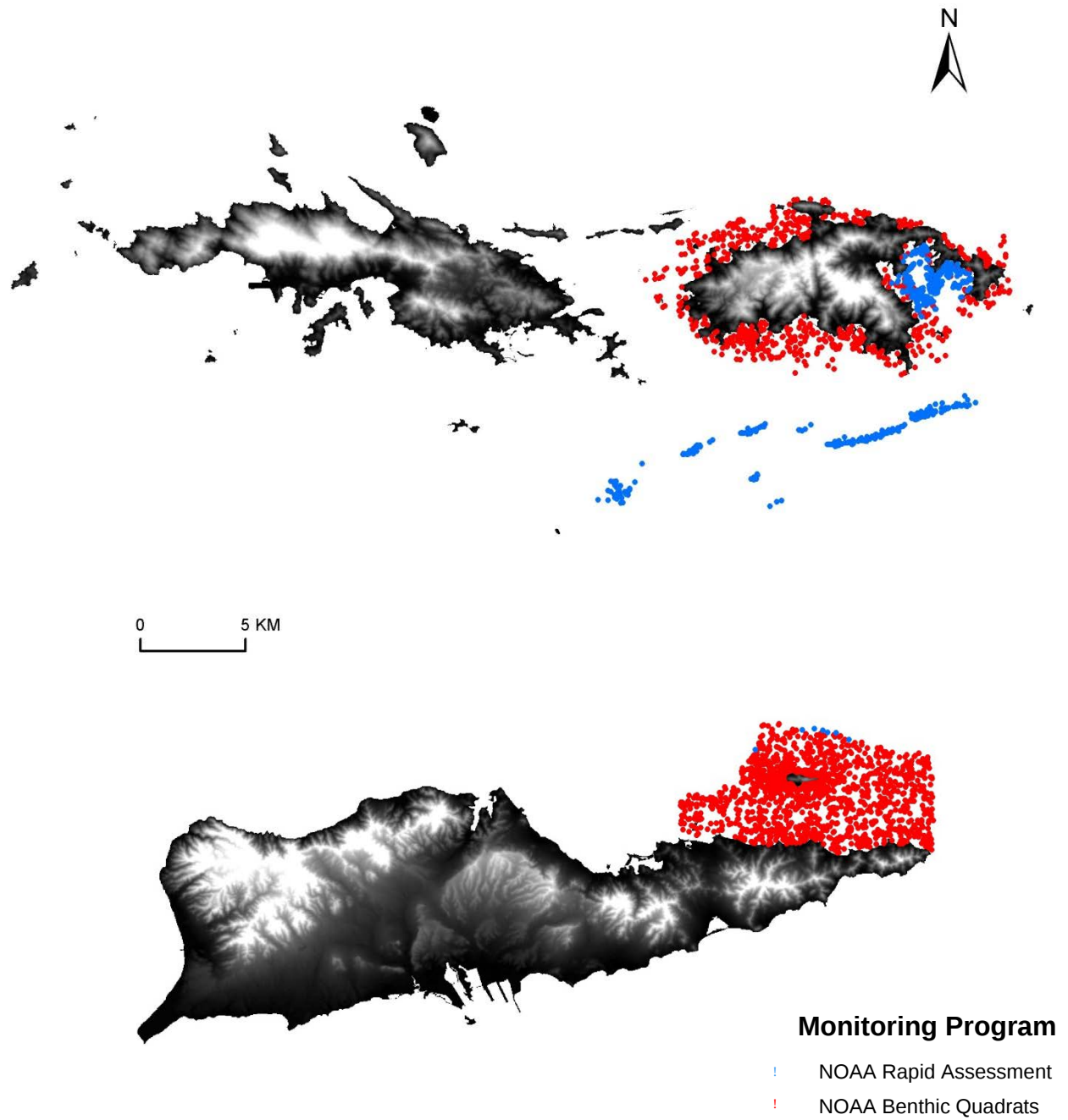
Project Webpage: Not available

Contacts: January Murray DFW, january.murray@dpnr.gov.vi



Graph 3. Number of georeferenced fish survey sites (effort) including receiver locations by island and habitat type in the U.S. Virgin Islands (1990-2009).

4.1.4 Benthic Communities including Coral & Seagrasses



NOAA/NCCOS/CCMA Biogeography Branch Caribbean Coral Reef Ecosystem Monitoring Project

Purpose: To characterize and monitor the distribution, abundance, composition and condition of benthic communities using underwater visual surveys. Benthic surveys are conducted using rapid survey techniques at some sites and multiple (n=5) 1 m² quadrats along fish survey transects at other sites.

Project Dates: 2001 - ongoing

Variables Measured: benthic community composition, height, disease, bleaching, depth, rugosity, abiotic footprint, biotic footprint, photography, marine debris, other impacts

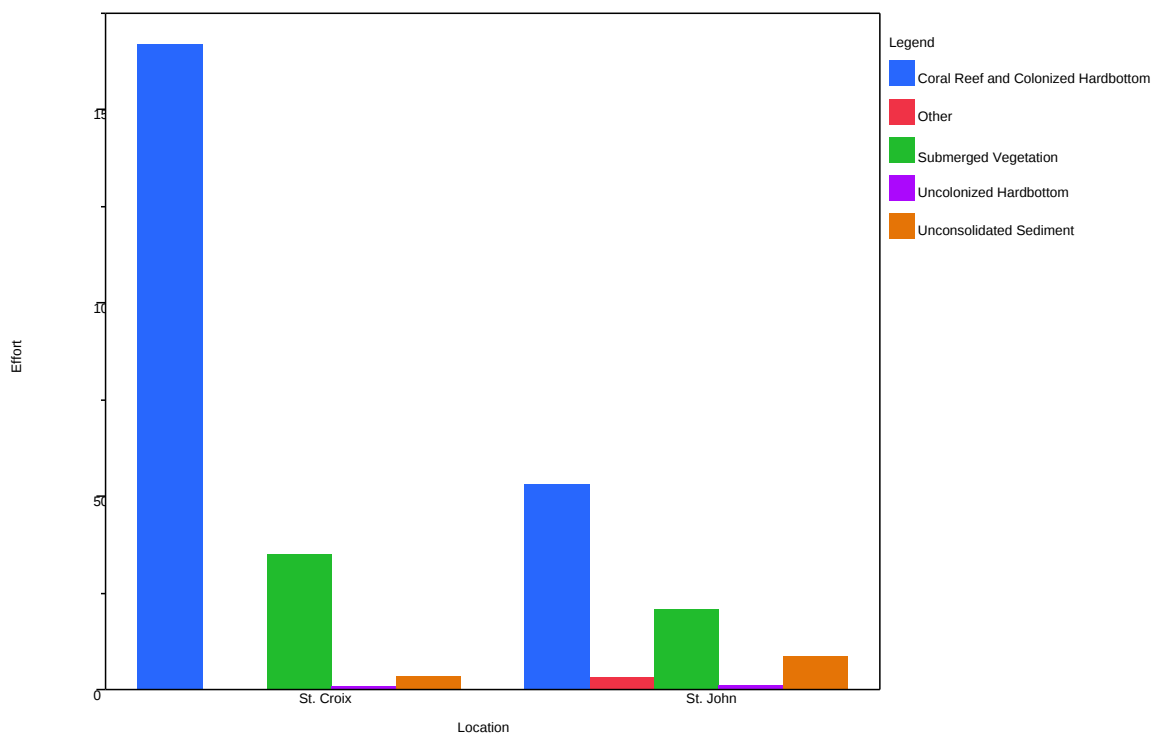
Location(s): St. John, St. Croix

Measurement Frequency: Biannually at St. Croix and Annually for St. John

Location of Data: http://www8.nos.noaa.gov/biogeopublic/query_habitat.aspx

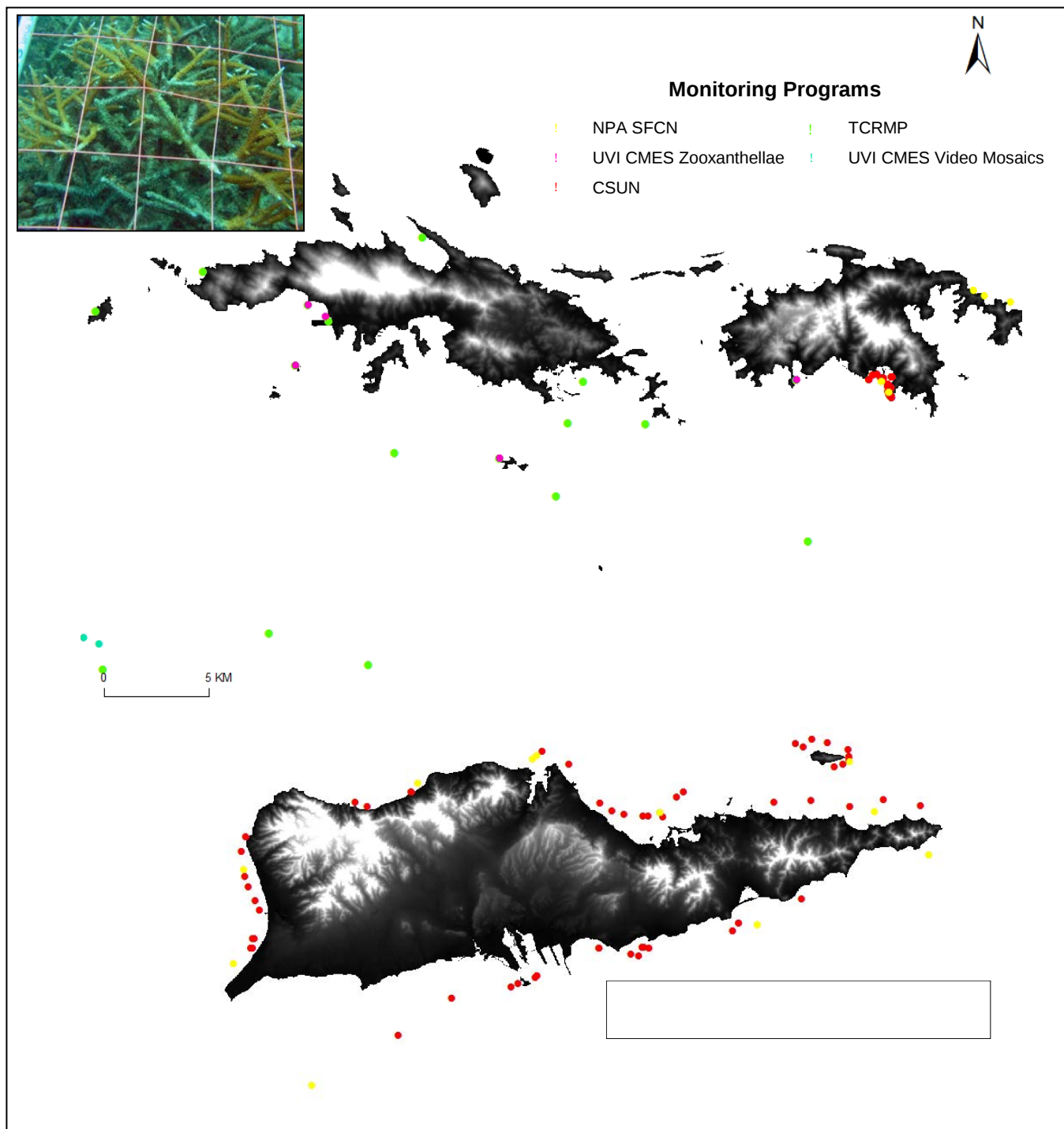
Contact: Chris Caldow chris.caldow@noaa.gov

Relevant Publication: Clark, R., Jeffrey, C., Woody, K., Hillis-Starr, Z. Monaco, M. 2009. [Spatial and Temporal Patterns of Coral Bleaching Around Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands . Bulletin of Marine Science 84\(2\),167-182.](#)



Graph 4. Number of georeferenced benthic community survey sites (effort) by island and habitat type in the U.S. Virgin Islands (1990-2009).

4.1.5 Corals



California State University Northridge (CSUN)

Purpose: Studying long-term dynamics of coral reef ecosystems, particularly growth and survival of juvenile corals and investigating effects of thermal stress and ocean acidification on corals. Funded by National Science Foundation Long Term Research in Environmental Biology program.

Project Dates: 1987- ongoing

Variables Measured: Coral fate, community dynamics (1987- ongoing), coral recruitment, demographics, juvenile growth, juvenile mortality (1994 - ongoing)

Location(s): St. John

Measurement Frequency: Annually

Project Webpage: <http://www.csun.edu/~mbgsclub/edmunds.html>

Contacts: Peter Edmunds peter.edmunds@csun.edu

Relevant Publication: Edmunds, P.J. 2007. [Evidence for a decadal-scale decline in the growth rates of juvenile scleractinian corals. Marine Ecology Progress Series 341, 1-13.](#)

U.S. Environmental Protection Agency & VI Dept. Planning and Natural Resources

Purpose: To evaluate a stony coral bioassessment protocol for application of biocriteria development in the USVI for Clean Water Act compliance and regulatory monitoring.

Project Dates: 2006-2006 (complete)

Variables Measured: Coral biocriteria – abundance, coral colony size, surface area, % live coral; community composition, water quality

Location(s): St. Croix

Measurement Frequency: As needed

Project Webpage: http://www.epa.gov/bioiweb1/coral/coral_biocriteria.html

Contacts: William Fisher fisher.william@epa.gov

Relevant Publication: Bradley, P., Fisher, W.S., Bell, H., Davis, W., Chan, V., LoBue C., Wiltse, W. 2009. [Development and implementation of coral reef biocriteria in U.S. jurisdictions. Environmental Monitoring & Assessment 150, 43-51.](#)

National Park Service (NPS) South Florida Caribbean Network (SFCN)

Purpose: Long-term coral reef monitoring using videotransects to determine whether percent cover of major taxonomic groups (e.g. coral, algae gorgonians, sponge, substrate), coral species diversity, coral community structure, and rugosity are changing through time within selected coral reef sites and entire parks. Track trends and severity in reef-associated covariates such as coral bleaching, coral disease and presence of the herbivorous sea urchin, *Diadema antillarum*. Maintain and archive a video record of the transects to allow for quantification and future analyses of benthic components not identified in this protocol.

Project Dates: 2003 - ongoing

Variables Measured: Percent coral and other benthic cover, mortality, urchin abundance, rugosity, community diversity and composition

Location(s): St. John and St. Croix

Measurement Frequency: Monthly

Project Webpage: <http://science.nature.nps.gov/im/units/sfcn/>

Contacts: Jeff Miller SFCN William_J_Miller@nps.gov

Relevant Publication: Miller, J., Waara, R., Muller, E., and Rogers, C. 2006. Coral bleaching and disease combine to cause extensive mortality on reefs in U.S. Virgin Islands: *Coral Reefs* 25:418.

University of the Virgin Islands (UVI-CMES) Video Mosaics

Purpose: To monitor changes in coral reef benthic mosaics at two mesophotic reef sites south of St. Thomas, USVI. Four permanently marked quadrats (5 x 5 m) in 30 - 43 m depth are videoed along overlapping horizontal swaths. A single image is created from multiple frames with a digital algorithm.

Project Dates: 2009 - ongoing

Variables Measured: Coral mosaic

Location(s): Shelf-edge south of St. Thomas

Measurement Frequency: Irregular

Project Webpage: Not available

Contacts: Tyler Smith tsmith@uvi.edu

Relevant Publication: Gleason A.C.R., Gracias N., Lirman D., Gintert B.E., Smith T.B., Dick M.C., Reid R.P. 2010. [Landscape video mosaic from a mesophotic coral ecosystem. *Coral Reefs* 29\(2\),253.](#)

University of the Virgin Islands (UVI-CMES) Zooxanthellae Symbiont Study

Purpose: To determine and distinguish coral zooxanthellae symbiont diversity and clade characteristics in collaboration with University of Miami, Rosenstiel School of Marine Sciences.

Project Dates: 2005 - 2009

Variables Measured: Zooxanthellae diversity

Location(s): St. Thomas, St. John

Measurement Frequency: Tri-annually

Project Webpage: Not available

Contacts: Tyler Smith tsmith@uvi.edu

Relevant Publication: Correa, A.M.S., Brandt, M.E., Smith, T.B., Thornhill, D.J. and Baker, A.C. 2009. [*Symbiodinium* associations with diseased and healthy scleractinian corals. *Coral Reefs* 28, 437-448.](#)

USVI Territorial Coral Reef Monitoring Program (TCRMP CMES Benthos Surveys)

Purpose: The goal of the territorial coral reef monitoring program is to provide long-term trend data on territorial coral reef condition and to facilitate a systematic evaluation of the effects of natural and human-induced stresses influencing the decline or recovery of coral reef ecosystems and complement other ongoing monitoring studies. Surveys commissioned by Virgin Islands Department of Planning and Natural Resources (DPNR) through funding provided by Coral Reef Conservation Program Monitoring Grants. The information obtained is intended to be useful for resource managers in the Virgin Islands and to NOAA as it continues to assess coral reefs on a global scale.

Project Dates: 2001-N/A

Variables Measured: Benthic cover, partial mortality, disease prevalence, % diseased, size, health

Location(s): St. Croix, St. John, St. Thomas

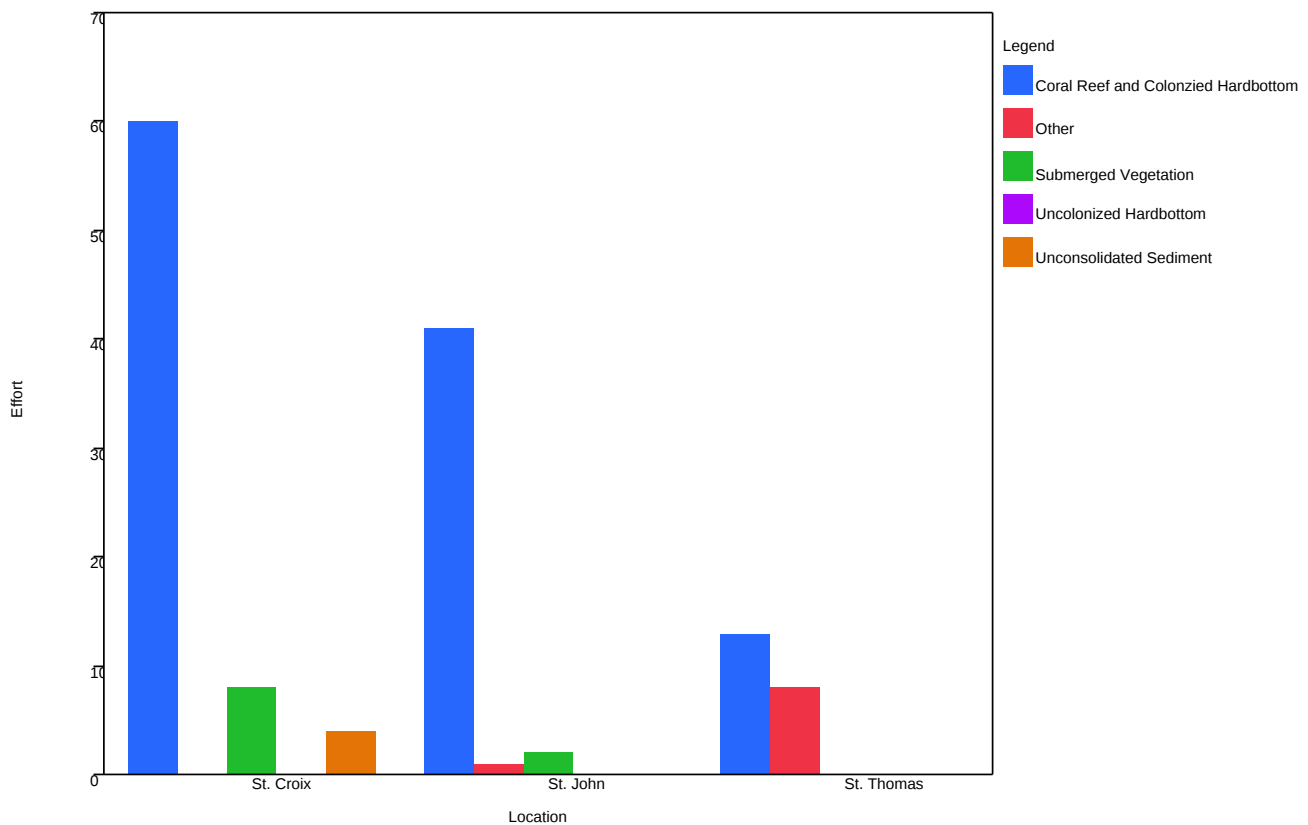
Measurement Frequency:

Project Webpage:

http://www.uvi.edu/sites/uvi/Documents/Research%20and%20Public%20Service/CMES/uvi_cmes_tcrmp_description.pdf

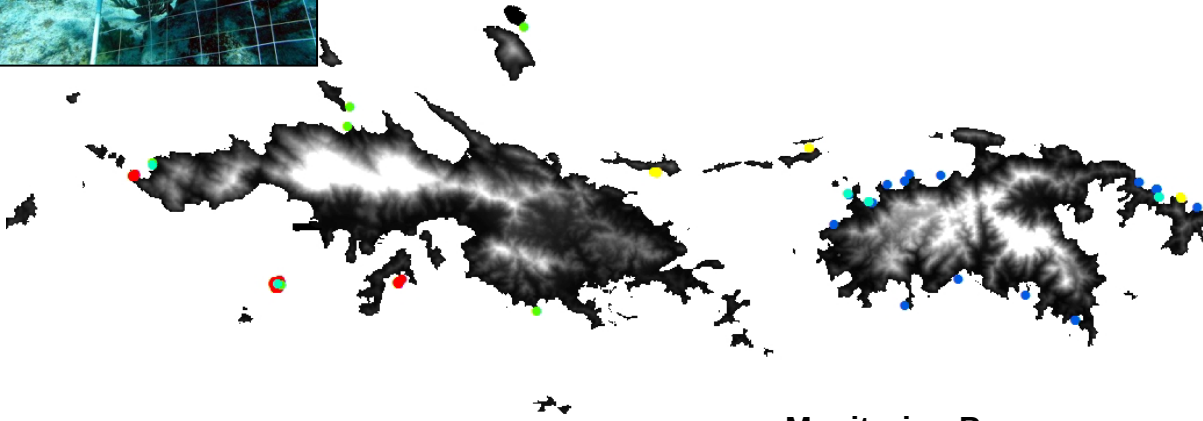
Contacts: Tyler Smith tsmith@uvi.edu

Relevant Publication: Smith T.B., Blondeau J., Nemeth R.S., Pittman S.J., Calnan J.N., Kadison E., Gass J. 2010. Benthic structure and cryptic mortality in a Caribbean mesophotic coral reef bank system, the Hind Bank Marine Conservation District, U.S. Virgin Islands. Coral Reefs 29(2), 289-308.



Graph 5. Number of georeferenced benthic survey sites (effort) by island and habitat type in the U.S. Virgin Islands (1990-2009).

4.1.6 *Acropora* spp.



Monitoring Program

- | | |
|-----------------|-----------------|
| ! USGS UVI CMES | ! TNC & UVI CDC |
| ! UVI CMES | ! USGS & NPS |
| ! NMFS SEFSC | |

0 5 KM



Monitoring Programs

- ! TNC & UVI CDC

U.S. Geological Survey (USGS) & University of the Virgin Islands (UVI-CMES)

Purpose: To document any predation, disease, bleaching and physical damage to elkhorn coral *Acropora palmata*.

Project Dates: 2007- 2009

Variables Monitored: Disease presence, physical damage, predation, bleaching, colony photograph, mortality, sea temperature

Location(s): St. John, St. Thomas

Monitoring Frequency: Monthly

Project Webpage: Not available

Contacts: Caroline Rogers, USGS Caribbean Field Office
caroline_rogers@usgs.gov & Alan Bright

U.S. Geological Survey (USGS) & National Park Service (NPS)

Purpose: *Acropora palmata* & *A. cervicornis* monitoring. Funded by Natural Resource Preservation Program, NOAA and Disney Wildlife Conservation Fund.

Project Dates: 2003 - ongoing

Variables Measured: colony size, % colony dead, cause of recent mortality, disease presence, lesions, lesion size, predatory snails, colony size, colony photograph

Location(s): St. John and British Virgin Islands

Measuring Frequency: Monthly

Project Webpage:

http://fl.biology.usgs.gov/Coral_Reef_Ecology/Virgin_Islands_National_Park/virgin_islands_national_park.html

Contacts: Caroline Rogers, USGS Caribbean Field Office
caroline_rogers@usgs.gov

The Nature Conservancy & University of the Virgin Islands Conservation Data Center

Purpose: To map the spatial location and population patterns of *Acropora palmata* in priority bays around St. Croix and St. Thomas.

Project Dates: 2006 - 2007

Variables Measured: GPS location, disease, colony size, live cover, predation, fragmentation, growth form, photographs

Location(s): St. Thomas, St. Croix

Measurement Frequency: As needed

Project Webpage: Not available

Contacts: Jeanne Brown TNC jeanne_brown@tnc.org & Stevie Henry UVI
CDCshenry@uvi.edu

University of the Virgin Islands (UVI CMES) *Acropora* Monitoring

Purpose: To understand the trajectory of *Acropora palmata*, *A. cervicornis*, and *A. prolifera* populations and threats to their health and persistence.

Project Dates: 2003- 2009

Variables Measured: Areal coverage, disease, partial mortality, predators, size

Location(s): St. Thomas, St. John

Measurement Frequency: Monthly
Project Webpage: Not available
Contacts: Tyler Smith, UVI tsmith@uvi.edu

NMFS Southeast Fisheries Science Center (NMFS SEFSC) – *Acropora cervicornis* growth study

Purpose: To monitor changes in growth, vitality, and habitat value of *Acropora cervicornis* in the US Caribbean as they changed in configuration through growth and disturbance. Observations along underwater transect. Data were intended to elucidate the relationship between colony configuration and fish assemblages to foster understanding of ecological services provided by the branching coral and guide manager's decisions and restoration activities.

Project Dates: 2005 - 2009

Variables Measured: Reef fish assemblage measures (abundance and body length), coral colony size, coverage, growth, mortality, and indications of stress (presence of disease or predation).

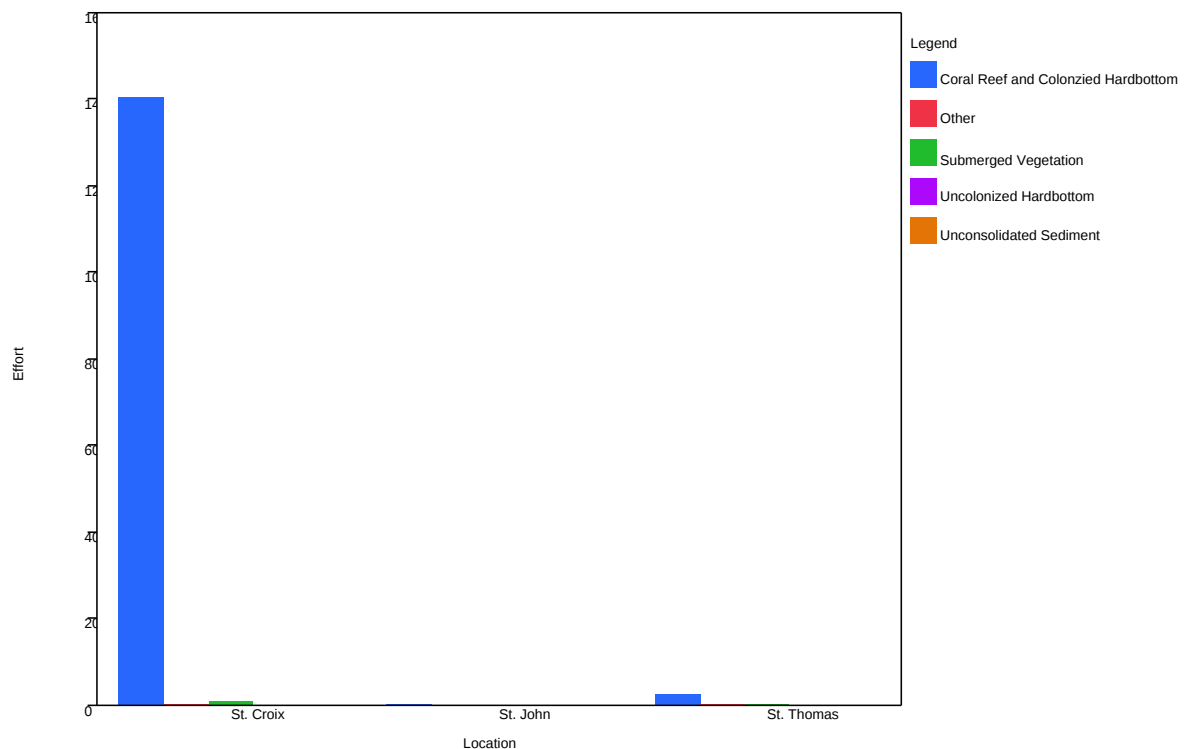
Location(s): St. Thomas, St. John

Measurement Frequency: Annually

Project Webpage: metadata available at:

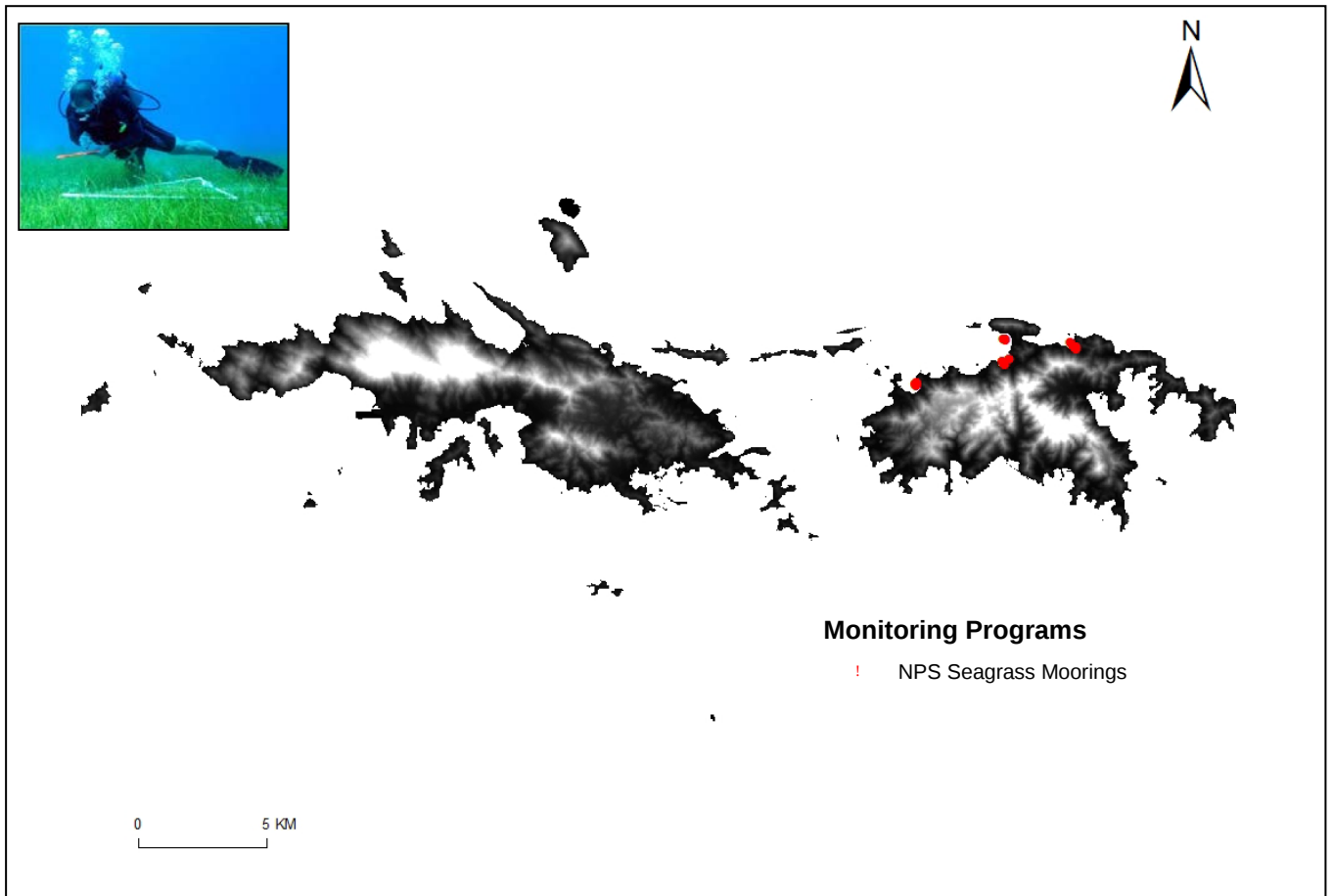
http://coris.noaa.gov/metadata/records/faq/acropora_cervicornis_monitoring_metadata_rev20120228.html

Contacts: Ron Hill ron.hill@noaa.gov



Graph 6. Number of georeferenced *Acropora* spp. survey sites/colonies (effort) by island and habitat type in the U.S. Virgin Islands (1990-2009).

4.1.7 Seagrasses



National Park Service (NPS) Seagrass Monitoring

Purpose: To determine the success of moorings for benthic community recovery

Project Dates: 2000 - ongoing

Variables Measured: Shoot counts, canopy height, algae % cover, sessile invertebrates, grazing

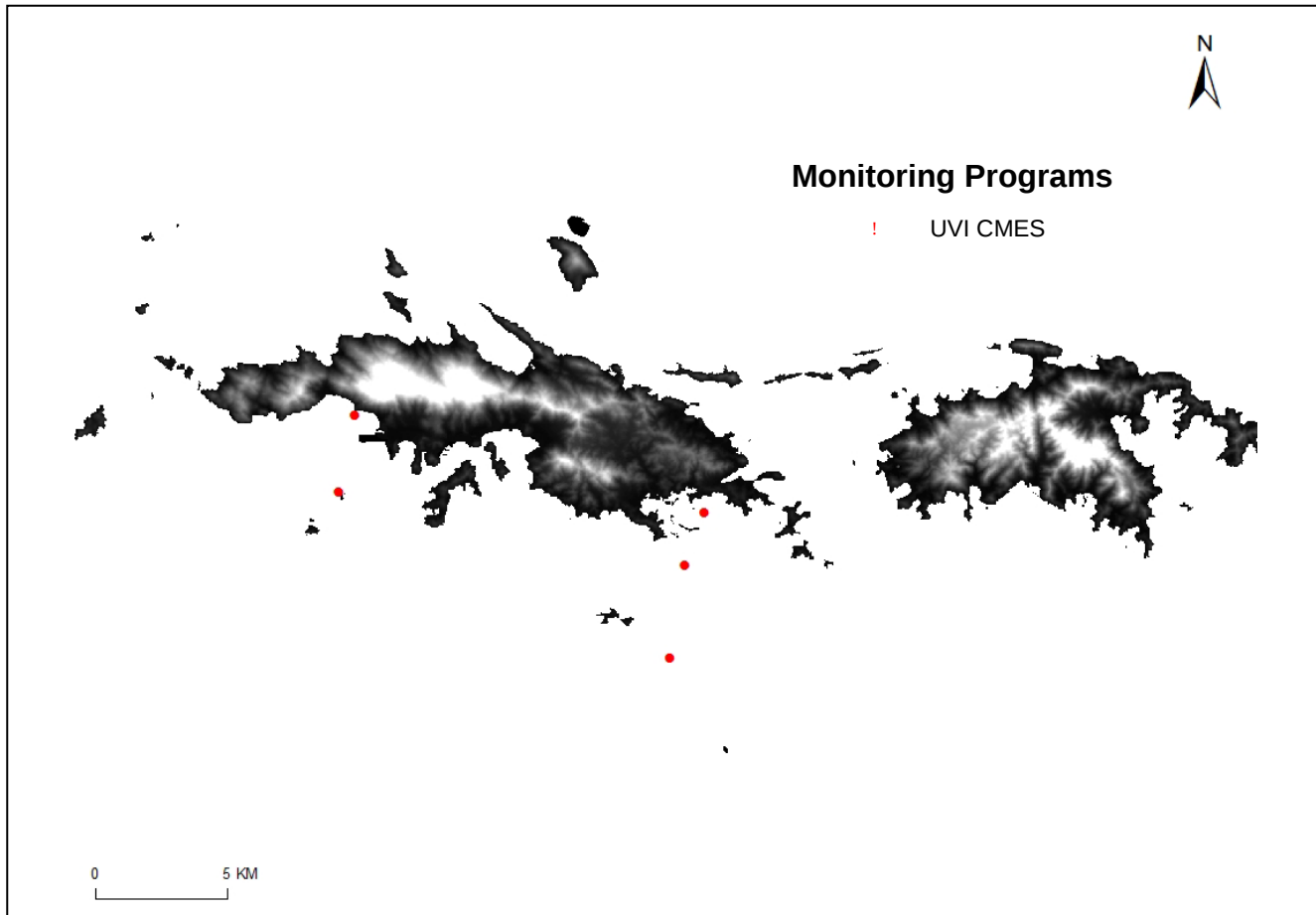
Location(s): St. John

Measurement Frequency: Bi-annually

Project Webpage: Not available

Contacts: Rafe Boulon rafe_boulon@nps.gov

4.1.8 Ciguatera



University of the Virgin Islands Center for Marine & Environmental Studies (UVI CMES)

Purpose: The overall goals are to investigate relationships among environmental stresses to coral reef systems in the USVI, the population dynamics of *Gambierdiscus*, fish toxicity, and associated cases of ciguatera fish poisoning in humans, and to use this information to develop an early warning or predictive capability for the prevention of human illness. Part funded by NOAA.

Project Dates: 2008- ongoing

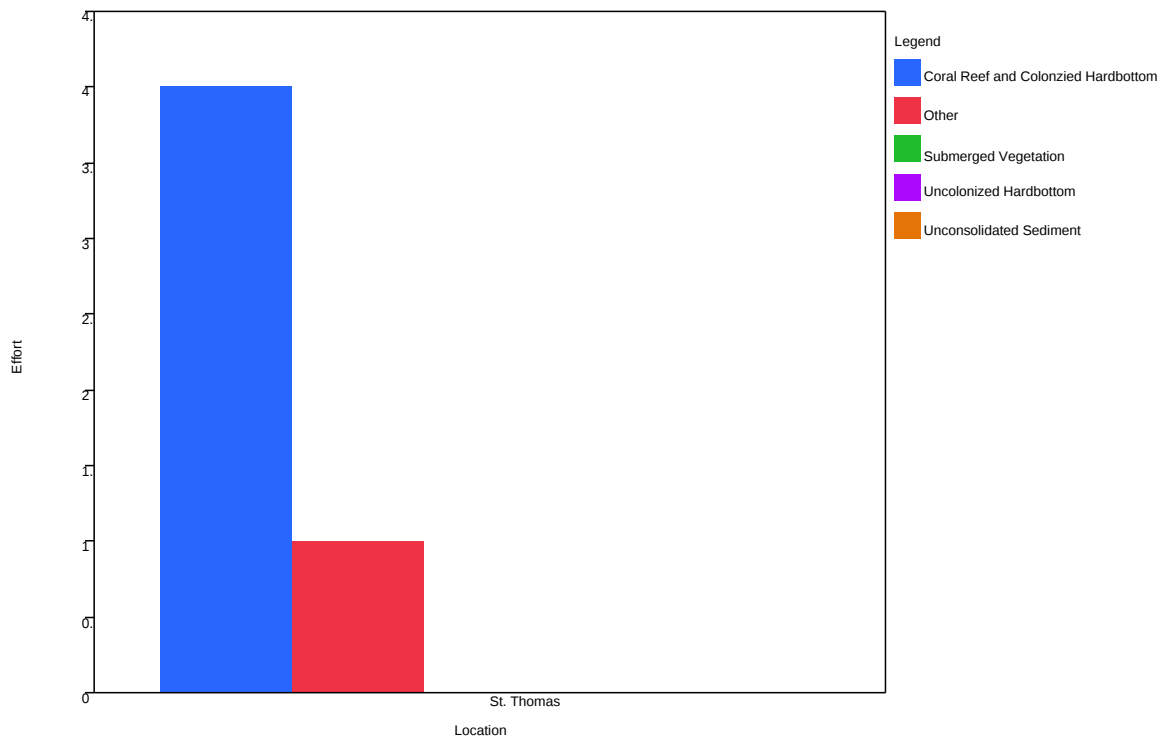
Variables Measured: *Gambierdiscus* abundance & distribution, macroalgal substrate, toxins from fish tissues

Location(s): St. Thomas

Measurement Frequency: As needed

Project Webpage: <http://www.fqu.edu/CiguaHAB/about.html>

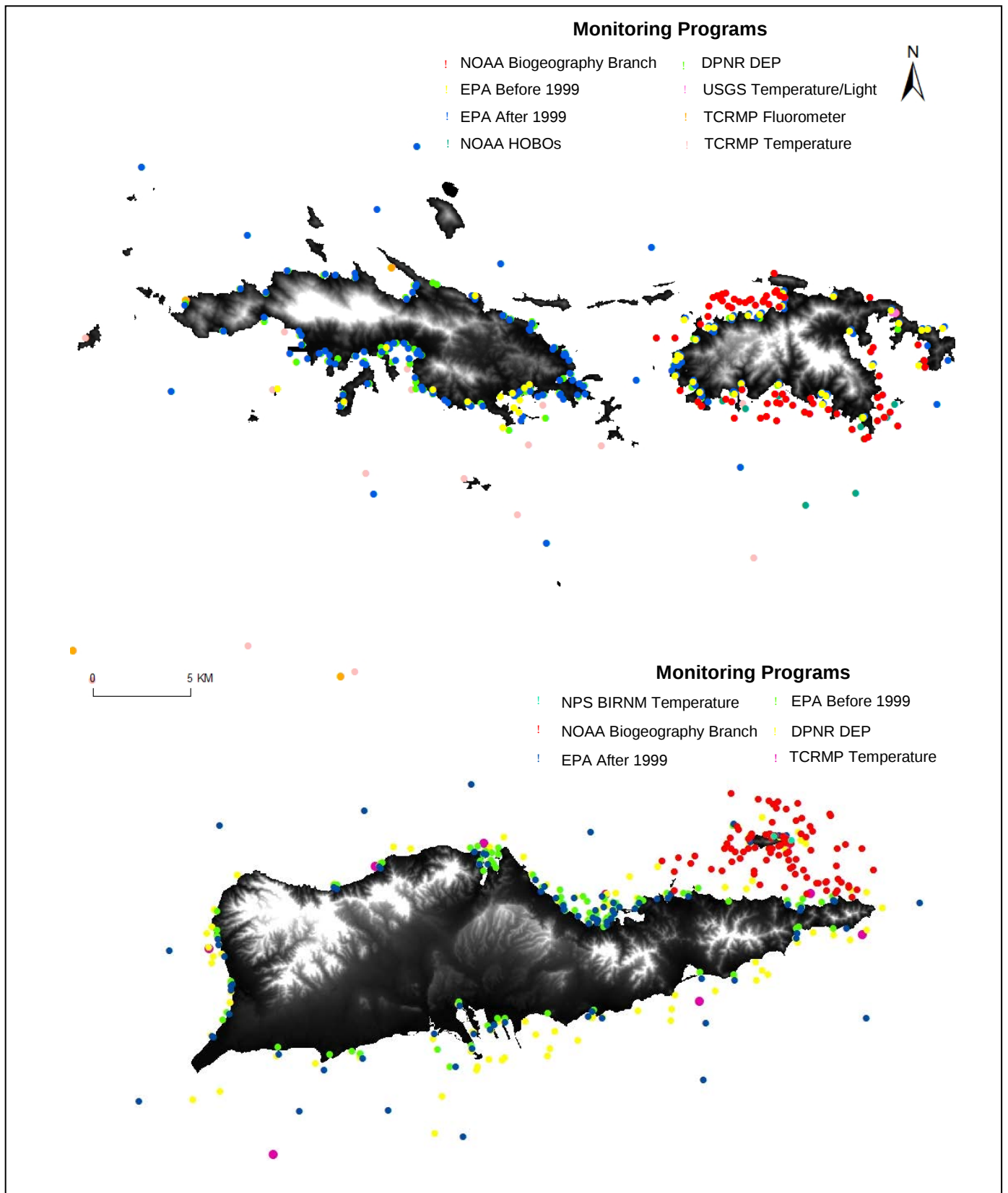
Contact: Tyler Smith tsmith@uvi.edu



Graph 7. Number of georeferenced ciguatera survey sites (effort) by island and habitat type in the U.S. Virgin Islands (1990-2009).

4.2 Physical & Oceanographic Variables

4.2.1 Water Quality



National Park Service Water Resources Division (WRD) & U.S. Geological Survey

Purpose: The mission of WRD is to preserve and protect NPS water resources and water dependent environments through watershed management programs (including water quality monitoring) based on needs at the park, network, region, and national levels. 31 sites were monitored from 1988 until 1996 and then sites were reduced to 15. Data available via STORET

<http://www.epa.gov/storet/dbtop.html>

Project Dates: 1988- 1999; 1999- (NB: records exist from 1975)

Variables Measured: Water temperature(°C), % cloud cover, depth, wind velocity and direction, sea waves severity, turbidity, transparency, dissolved oxygen, pH, salinity, total nonfiltrable residue, ammonia, nitrite, nitrate, phosphorous, fecal coliform, fecal streptococci

Location(s): St. Thomas, St Croix, St John

Measurement Frequency: Irregular

Project Webpage: <http://www.nature.nps.gov/water/horizon.cfm>

VI Government Department of Environmental Protection (DPNR-DEP) Ambient Monitoring Program

Purpose: The Ambient Monitoring Program generates a comprehensive and representative assessment of the water quality in the US Virgin Islands. Water quality monitoring DPNR performs quarterly water quality monitoring of sixty-four (64) stations around St. Croix, fifty-seven (57) stations around St. Thomas, and nineteen (19) around St. John. At each site samples are collected from surface water and data are uploaded into STORET online database maintained by U.S. EPA

<http://www.epa.gov/storet/dbtop.html>

Project Dates: 2000- ongoing (first started in 1968)

Variables Measured: Turbidity, dissolved oxygen, pH, depth, temperature, salinity, secchi depth, fecal coliform and enterococci, total suspended solids, total phosphorous

Location(s): St. Thomas, St. John, St. Croix

Measurement Frequency: Quarterly and episodic events.

Project Webpage: <http://environmental-protection.dpnr.gov.vi/pages/water-quality-mgmt-program-252>

Contact: Anita Nibbs, DPNR anita.nibbs@dpnr.gov.vi

NOAA/NCCOS/CCMA Biogeography Branch Water Quality Samples

Purpose: To record water parameters to describe environmental conditions at fish & benthic survey sites. Using the Hydrolab Datasonde 4a, measurements were taken at the surface and seafloor.

Project Dates: 2003-2005

Variables Measured: Depth (m), temperature (C), conductivity (mS/cm), turbidity (NTU), and chlorophyll a (mg/l)

Location(s): St. John and St. Croix

Measurement Frequency: Annually between 2003 and 2005

Project Webpage:

http://www8.nos.noaa.gov/biogeo_public/water_quality_query.aspx

Contact: Chris Caldwell chris.caldow@noaa.gov

NOAA/NCCOS/CCMA Biogeography Branch (NOAA HOBOS)

Purpose: To record water temperature around St. John using HOBO temperature loggers attached to mooring lines simultaneously used for fish tracking.

Project Dates: 2006-2009

Variables Measured: Sea temperature (°C)

Location(s): St. John

Measurement Frequency: Continuous

Project Webpage: Not available

Contact: Chris Caldwell chris.caldow@noaa.gov

National Park Service Buck Island Reef National Monument (NPS BIRNM) Sea temperature monitoring

Purpose: To record water temperature in the Buck Island Reef National Monument using temperature loggers.

Project Dates: 1991- ongoing

Variables Measured: Sea temperature (°C)

Location(s): Buck Island Reef National Monument, St. Croix

Measurement Frequency: Continuous

Contact: Ian Lundgren ian_lundgren@nps.gov

University of the Virgin Islands Center for Marine & Environmental Studies (UVI-CMES)

Purpose: Monitoring water parameters (Water Temperature).

Monitoring Dates: 2005-N/A

Variables Monitored: Sea temperature (°C)

Location(s): STT (2005-N/A), STJ (2006-N/A), STX (2007-N/A)

Monitoring Frequency: Continuous

Project Webpage: Not available

Contact: Tyler Smith tsmith@uvi.edu

University of the Virgin Islands Center for Marine & Environmental Studies (UVI-CMES)

Purpose: Monitoring water parameters (Turbidity, Fluorescence).

Monitoring Dates: 2006 - ongoing

Variables Monitored: Fluorometer-chlorophyll fluorescence, turbidity

Location(s): St. Thomas

Monitoring Frequency: Continuous

Project Website: Not available

Contact: Tyler Smith tsmith@uvi.edu

U.S. Geological Survey (USGS Southeast Ecological Science Center)

Purpose: Sea temperature monitoring was conducted during the project “Trophic coupling and habitat connectivity among coral reef, mangrove, and seagrass fishes and benthic invertebrate communities of the Virgin Islands National Park (VIIS) and Coral Reef National Monument (VICR)” conducted by the USGS Southeast Ecological Science Center in collaboration with University of Florida, Louisiana State University, NPS and NOAA.

Project Dates: 2008- 2009

Variables Measured: Water column temperature, light

Location(s): St. John

Measurement Frequency: Continuous

Project Webpage:

http://fl.biology.usgs.gov/coastaleco/Staff/demopoulos/usvi_vicr.html

Contact: Amanda Demopoulos amandad@usgs.gov

U.S. Environmental Protection Agency (EPA) Environmental Monitoring & Assessment Program (EMAP)

Purpose: EMAP's goal was to develop the scientific understanding for translating environmental monitoring data from multiple spatial and temporal scales into assessments of current ecological condition and forecasts of future risks to our natural resources. EMAP developed indicators to monitor the condition of ecological resources.

Project Dates: 2004

Variables Measured: Chemical contaminants, sediment dwelling marine invertebrates, toxicity, light, sediment composition, nitrogen, phosphate, metals, salinity, temperature, Ph, dissolved oxygen.

Project Website: Data available via STORET online database maintained by U.S. EPA <http://www.epa.gov/storet/dbtop.html>

U.S. Environmental Protection Agency (EPA)

Purpose: To collect water samples in accordance with the Clean Water Act. Sampling conducted by The Cadmus Group in 2009 and Tetra Tech Inc in 2007 and 2010.

Project Dates: 2007 - 2010

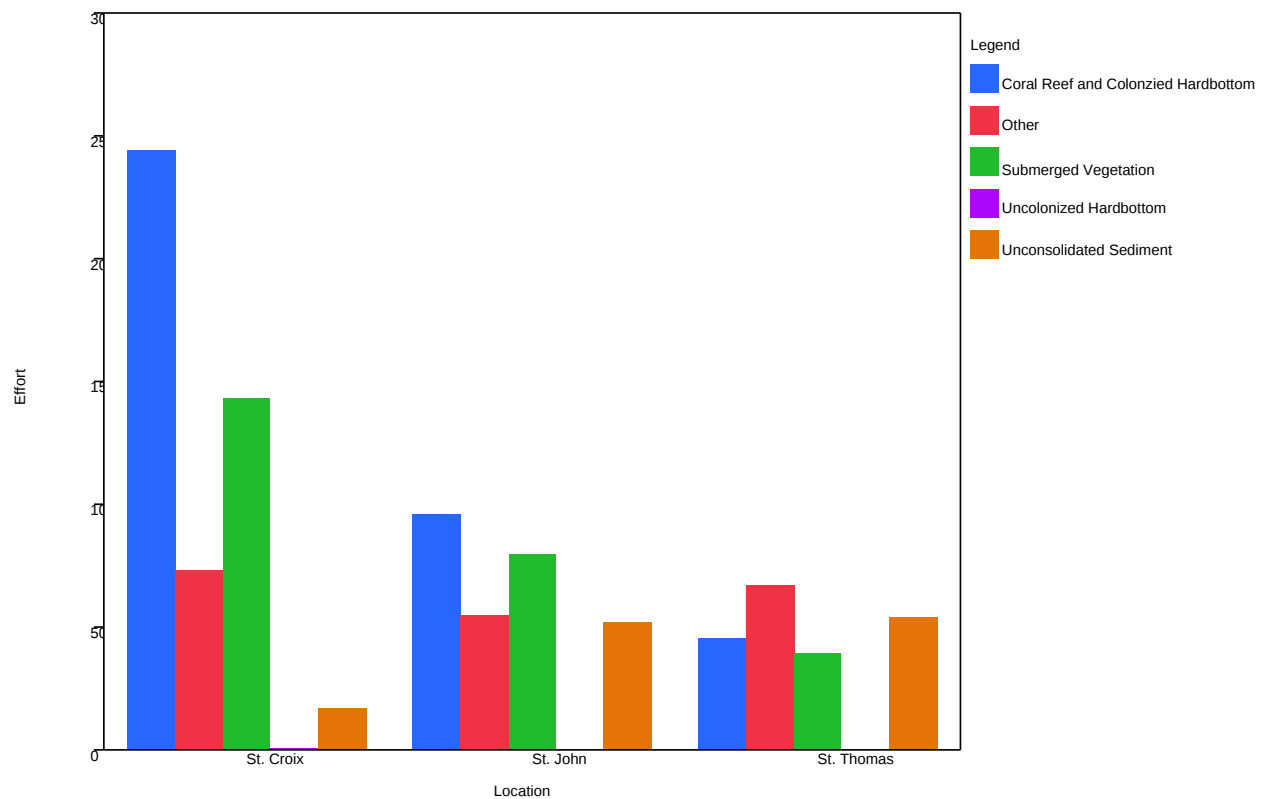
Variables Measured: Chlorophyll a, phosphorus, nitrogen, nitrites, carbon, ammonia, fecal and enterococci bacteria, total suspended/dissolved solids, turbidity, Secchi depth, temperature, salinity, dissolved oxygen, biochemical oxygen demand, pH, light.

Location(s): St. Thomas, St. Croix, St. John

Measurement Frequency: Annually

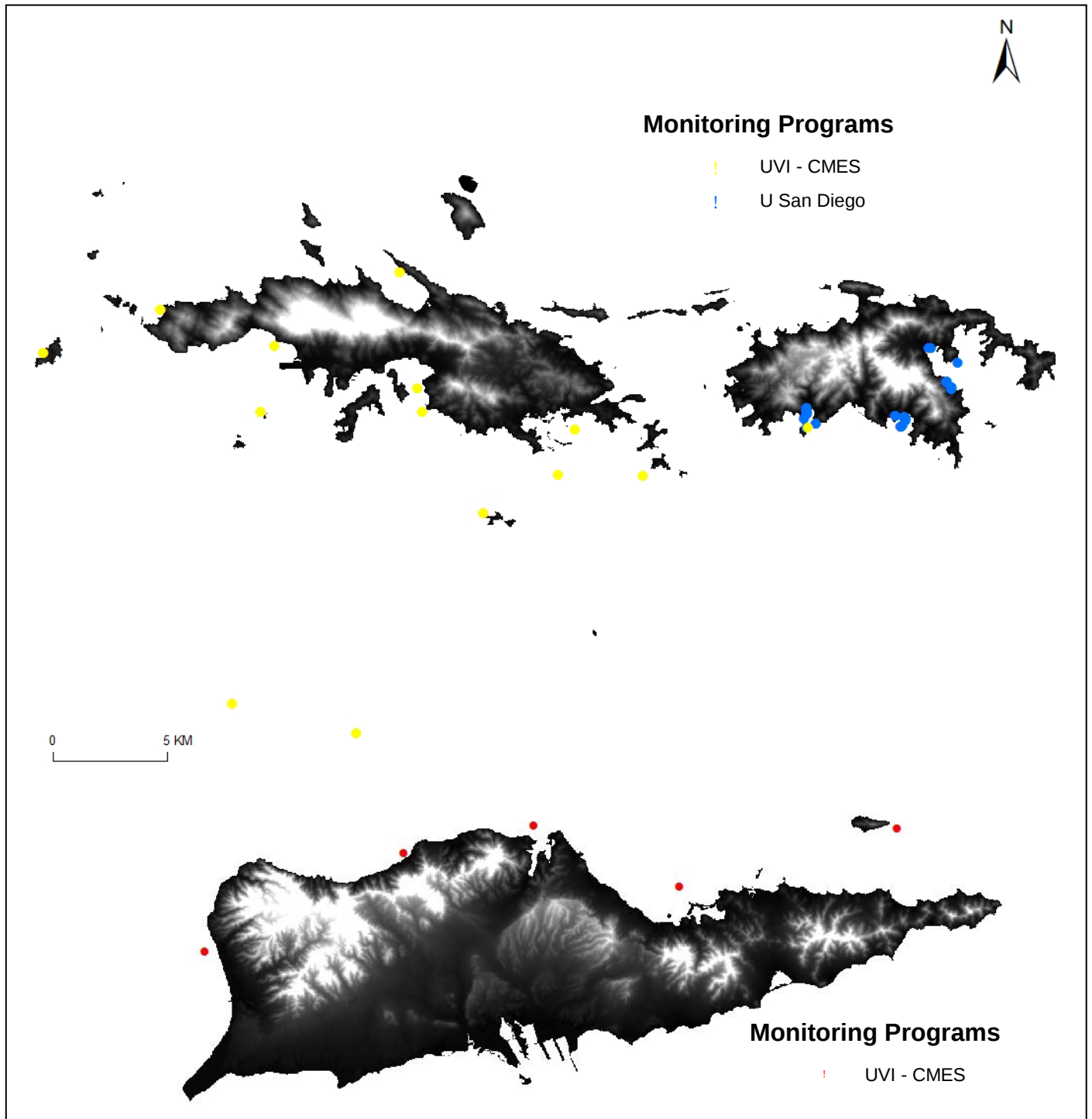
Project Website: Data available via STORET online database maintained by U.S. EPA <http://www.epa.gov/storet/dbtop.html>

Contact: Tyler Smith tsmith@uvi.edu



Graph 8. Number of georeferenced water quality sample sites (effort) by island and habitat type in the U.S. Virgin Islands (1990-2009).

4.2.2 Sediment



University of the Virgin Islands Center for Marine & Environmental Studies

Purpose: Sedimentation monitoring

Project Dates: 2004 - ongoing

Variables Monitored: Sedimentation

Location(s): St. Thomas (start 2004), St. Croix (start 2006)

Measurement Frequency: Monthly

Project Website: Not available

Contact: Tyler Smith tsmith@uvi.edu

Relevant Publication: Smith T.B., Nemeth R.S., Blondeau J., Calnan J.M., Kadison E., Herzlieb S. 2008. [Assessing coral reef health across onshore to offshore stress gradients in the US Virgin Islands. Marine Pollution Bulletin 56:1983-1991.](#)

University of San Diego, Dept. Marine Science & Environmental Studies

Purpose: To establish a baseline of data from which to evaluate how development in watersheds on St. John have impacted, quantity, quality and spatial variability of sedimentation in bays with reefs. Part funded by NOAA.

Project Dates: 2007- 2010

Variables Measured: Sediment (grain size, % organic matter, % carbonate, type, accumulation, mineralogy), water samples (suspended sediments, nutrients), benthic composition (% coral, algae, substrate), water column (temperature, salinity, total dissolved solids, dissolved oxygen)

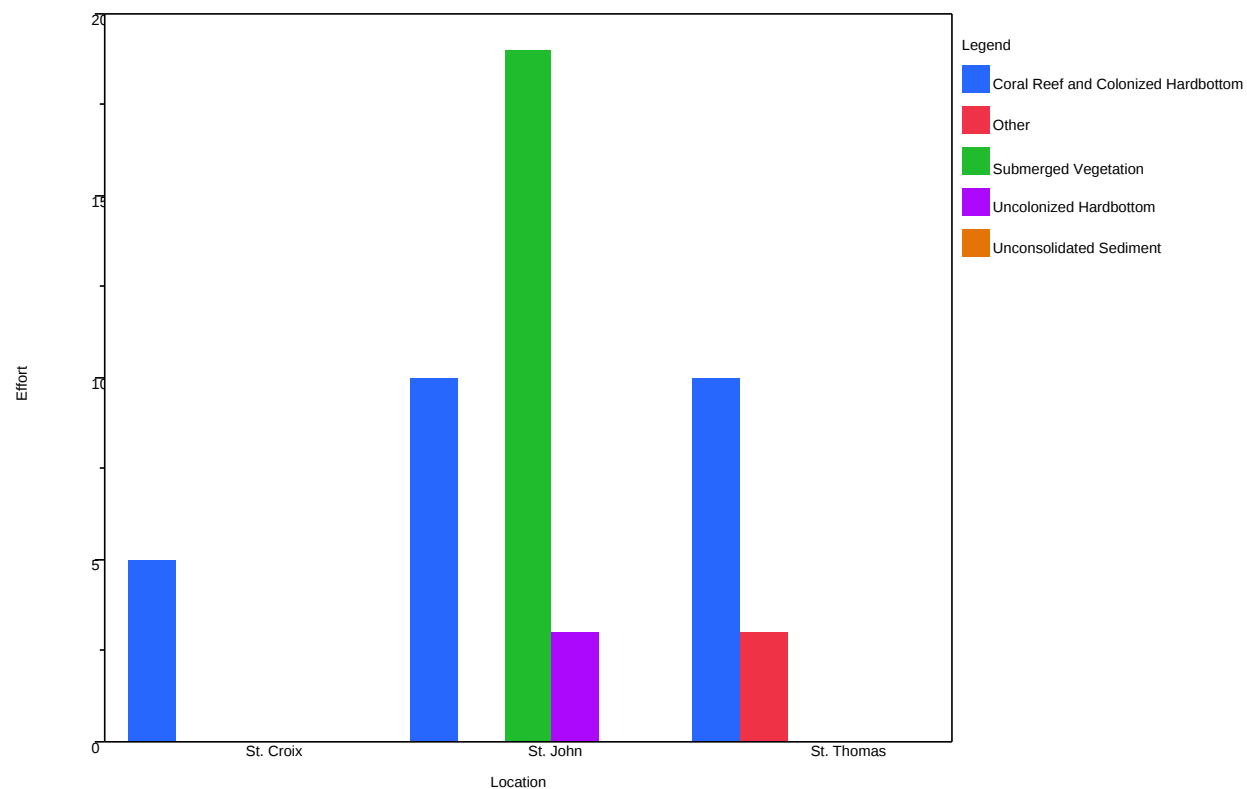
Location(s): St. John

Measurement Frequency: As needed

Project Website: Not available

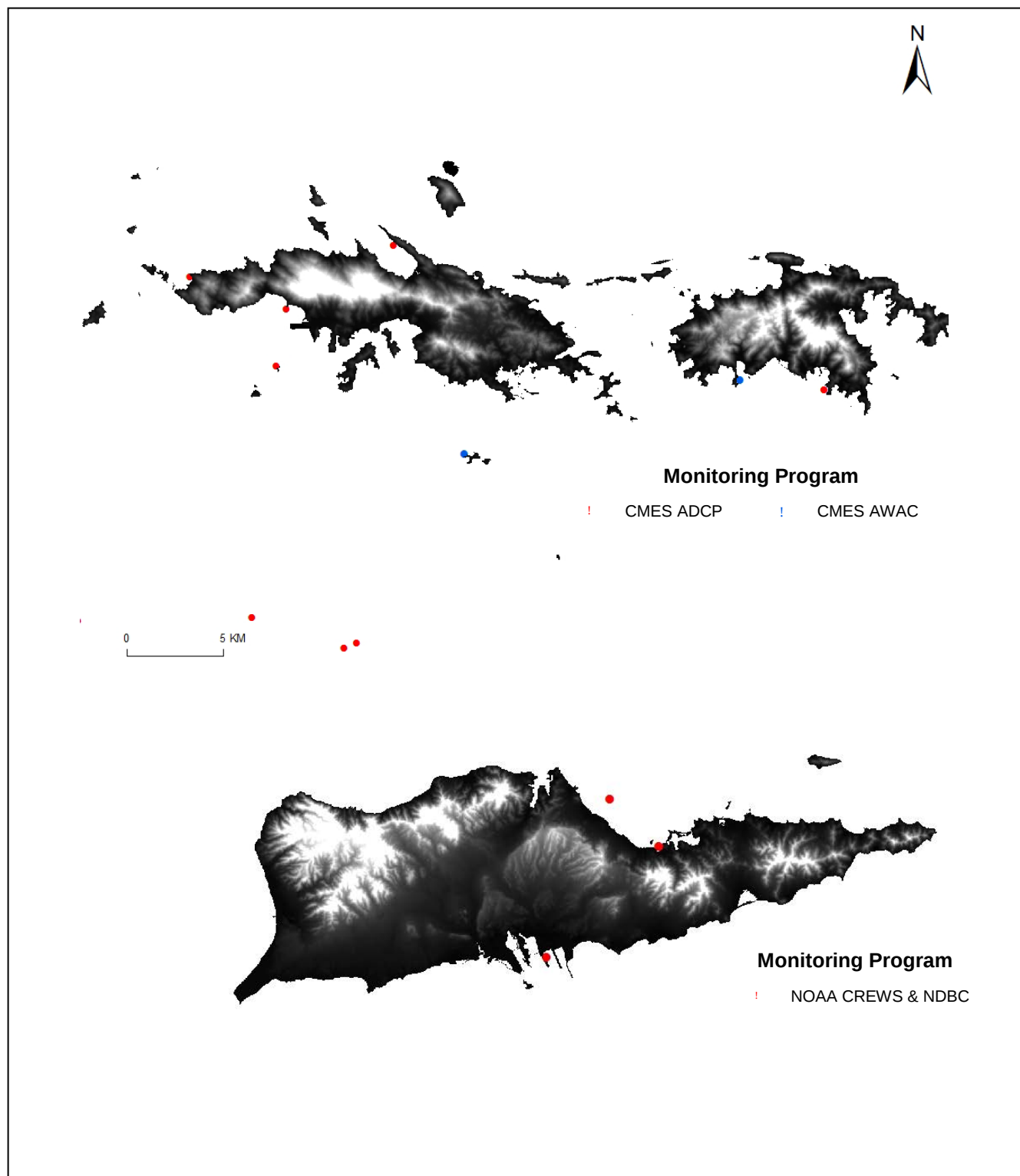
Contact: Chris Caldow chris.caldow@noaa.gov

Relevant Publication: Gray, S. 2010. [A comparative study of fringing reefs below developed vs. undeveloped watersheds, U.S. Virgin Islands.](#) Final Report submitted to NOAA Coral Reef Conservation Program.



Graph 9. Number of georeferenced sediment sample sites (effort) by island and habitat type in the U.S. Virgin Islands (1990-2009).

4.2.3 Oceanographic



NOAA Coral Reef Early Warning System (CREWS)

Purpose: To predict real time environmental data and predict effects of environmental events on coral reefs. The CREWS program, as a part of NOAA's Coral Reef Watch and Coral Health And Monitoring Programs (CHAMP), is designed to collect real time environmental data from prime coral reef sites throughout the world, analyze patterns and trends via expert systems and predict the effects of environmental events on coral reefs such as bleaching, fish and invertebrate spawning and migration. An ICON (Integrated Coral Observing Network) station is located in Salt River Bay, Northeast St. Croix.

Monitoring Dates: 2001 - ongoing

Variables Monitored: Air temperature, sea temperature, barometer, wind direction, speed and gusts, depth, PAR, rain amount, duration and intensity, shallow and deep CTD.

Location(s): St. Croix

Monitoring Frequency: Continuous

Project Webpage: <http://ecoforecast.coral.noaa.gov/index/0/SRVI2/station-home>

NOAA National Data Buoy Center (NDBC)

Purpose: To monitor oceanic and meteorological conditions.

Variables Measured: Atmospheric pressure, air and water temperature, wind direction and strength.

Location(s): St. Thomas, St. Croix

Measurement Frequency: Continuous

Project Website: <http://www.ndbc.noaa.gov/>

University of the Virgin Islands Center for Marine & Environmental Studies (CMES)

Purpose: To monitor ocean currents in collaboration with NOAA Atlantic Oceanographic and Meteorological Laboratory's (AOML) Physical Oceanography Division.

Monitoring Dates: 2005 - ongoing

Variables Measured: ADCP: Current, temperature, pressure

Location(s): St. Croix, St. John, St. Thomas

Measurement Frequency: Continuous

Project Website:

http://www.aoml.noaa.gov/phod/highlights/project/load.php?pFullStory=20100515_20100615_ADCP_passages_Smith.html

Contact: Nasseer Idrisi, nidrisi@uvi.edu

University of the Virgin Islands Center for Marine & Environmental Studies (CMES)

Purpose: To monitor ocean currents

Project Dates: 2008 - ongoing

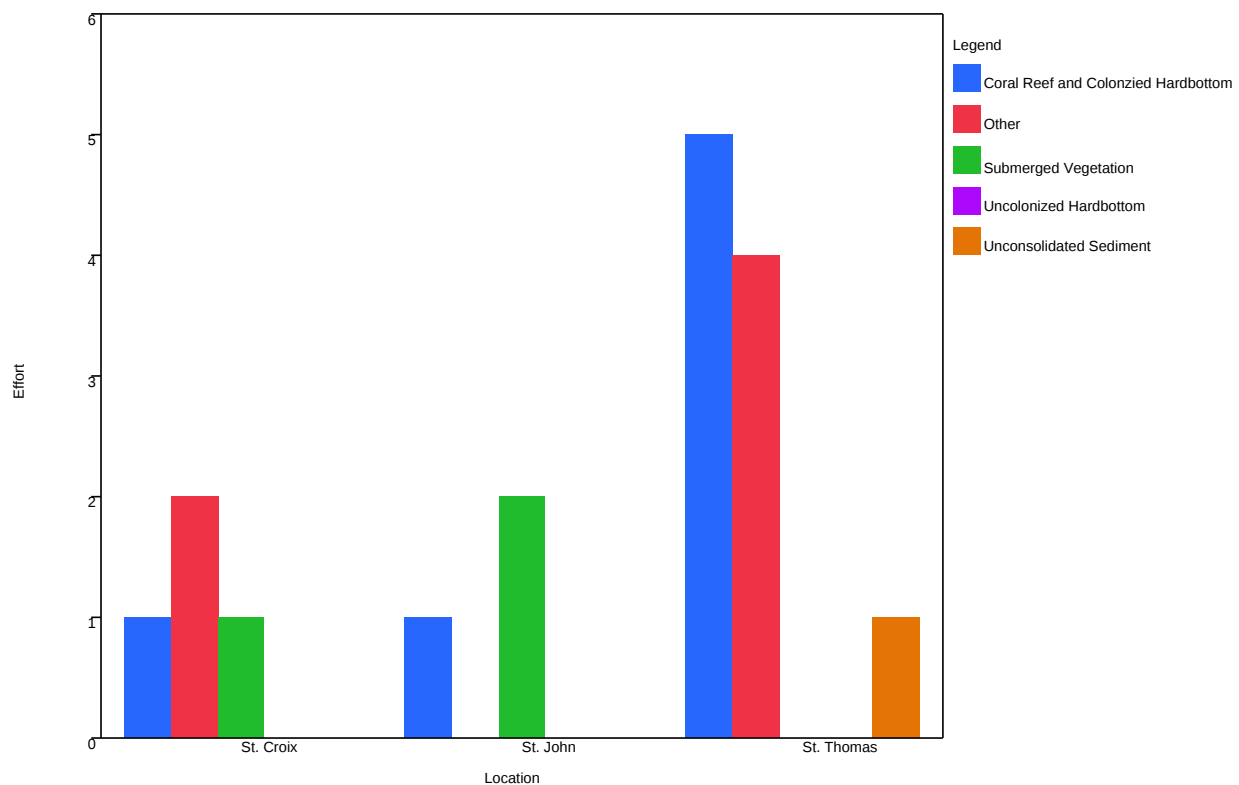
Variables Measured: AWAC: surface waves, surface currents, subsurface currents

Location(s): St. Thomas, St. John

Measurement Frequency: Continuous

Project Website: Not available

Contact: Nasseer Idrisi, nidrisi@uvi.edu

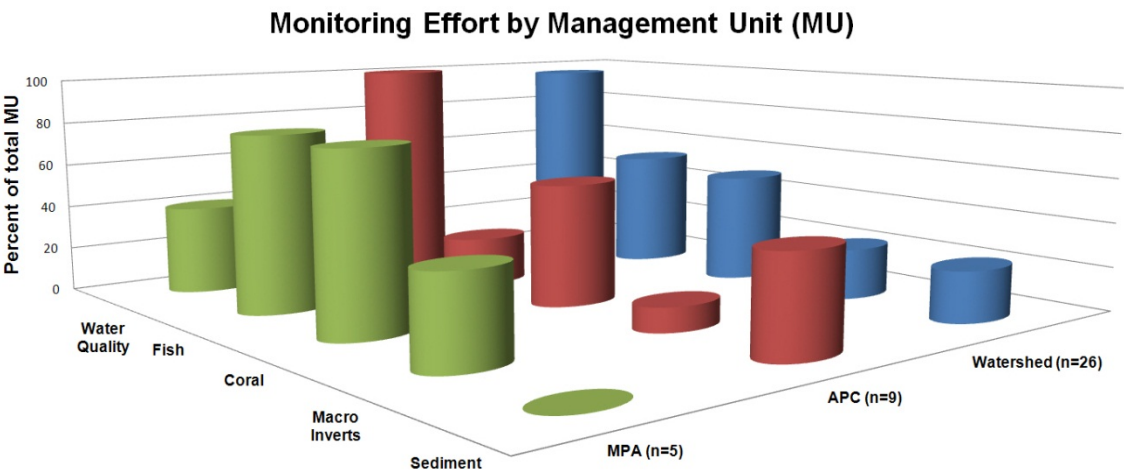


Graph 10. Number of georeferenced oceanographic/meteorological units (effort) by island and habitat type in the U.S. Virgin Islands (1990-2009).

5. Monitoring and Surveillance Activities by Management Units

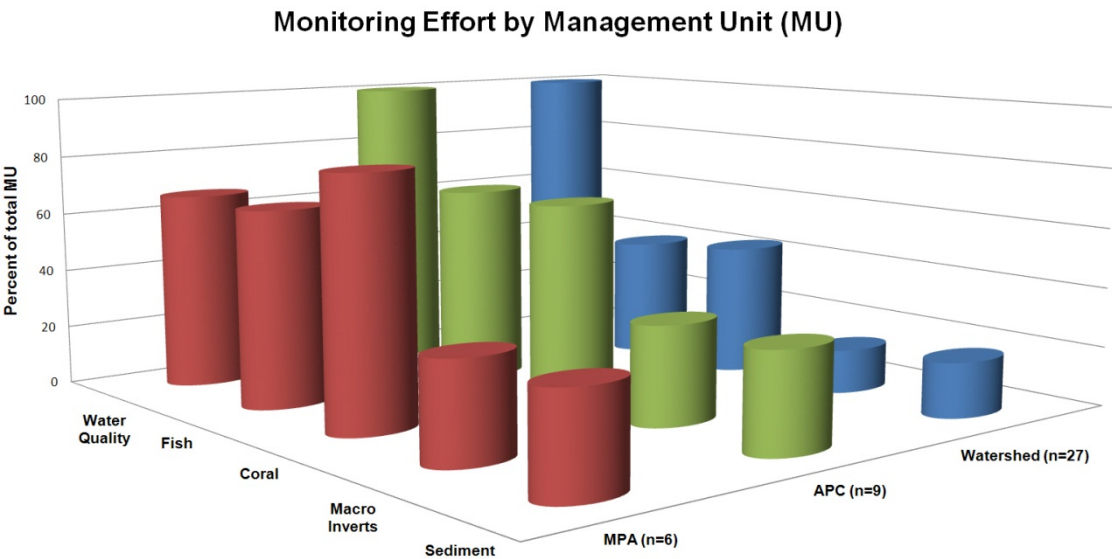
5.1 St. Thomas & St. John

Surveillance and monitoring effort grouped according to the management unit within which they are located indicates that effort for biological variables is greatest within marine protected areas (primarily the National Parks), yet sediment monitoring is lowest in the National Parks. Areas of Particular Concern (Territorial Government) receive highest effort for water quality monitoring and lower effort for biological variables (fish & macroinvertebrates).



5.2 St. Croix

On St. Croix, APCs overlap substantially with MPAs and therefore differences in effort by management unit are less pronounced. APCs and watersheds receive the highest effort for water quality monitoring, but considerably less sampling of sediments and biological variables has taken place among the watersheds indicating that spatial gaps likely exist around St. Croix where some watersheds are not well sampled.



6. Gaps in monitoring

6.1 Spatial Coverage

Biological variables (reef fish, benthic communities, & macro invertebrates)

Surveillance and monitoring of reef fishes, corals, and macro invertebrates occurred throughout the U.S Virgin Islands, but these efforts were inequitably distributed among islands and management units. Reef fishes in areas managed by the National Park Service (St. John and Buck Island, St. Croix), as well as the northern portion of the territorial East End Marine Park (Teague Bay, St. Croix) have been disproportionately and intensively surveyed during the past 10 years in comparison with other areas of the U.S. Virgin Islands. Although the Territorial Coral Reef Ecosystem Monitoring Program (TCREMP) had several permanent monitoring sites around St. Croix, and St. Thomas, major spatial gaps in reef fish monitoring existed for those islands. For example, fish in most of the territorially managed areas such as the Areas of Particular Concern (APCs) in St. Thomas were not monitored. Likewise, fishes throughout much of the island of St. Croix have not been surveyed, except for the northeast portion of the East End Marine Park and Buck Island Coral Reef National Monument. Regular monitoring of fish spawning aggregations occurred only at the Hind Bank and Grammanik Bank spawning aggregations along the shelf south of St. Thomas conducted by UVI-CMES. Lang Bank and Mutton Snapper spawning sites on St. Croix have received little in-situ observation and few other sites in the region are known. Permanent long-term monitoring sites that have been surveyed regularly for longer than a decade are rare. Of note however, is the fact that reef fishes have been monitored at four permanent sites in St. John since 1988 (Friedlander and Beets 2008).

Overall, coral assemblages have been well monitored throughout the U.S Virgin Islands by Federal and Territorial agencies, yet substantial spatial gaps exist for characterization and monitoring of benthic communities across the region. During the past ten years, benthic communities have been disproportionately and intensively surveyed in areas managed by the National Park Service (St. John and Buck Island, St. Croix), as well as the northern portion of the territorial East End Marine Park (Teague Bay, St. Croix), in comparison with other areas of the U.S. Virgin Islands. TCREMP (DPNR/UVI-CMES) have a few permanent monitoring sites around St. Croix, and St. Thomas where monitoring of benthic communities is conducted, but benthic assemblages in most of the territorially managed areas such as the Areas of Particular Concern (APCs) in St. Thomas remain largely un-surveyed or monitored. Spatial gaps exist among the islands for targeted *Acropora* monitoring, with a paucity of monitoring sites occurring in St. Croix compared with St. John and St. Thomas. Given the listing of *Acropora* species as being endangered or threatened, more targeted monitoring and surveillance of acroporid corals is needed to determine spatial distributions, abundance and health throughout the U.S. Virgin Islands.

Seagrass and algal communities are important components of the marine natural resources within the U.S Virgin Islands and are interconnected with coral reefs to form functioning coral reef ecosystems. Their primary productivity contributes important and sometimes essential food that support fish assemblages occurring in neighboring coral reefs and other hard bottom habitats. A huge spatial gap exists for seagrass monitoring in the USVI. Beyond the broad-scale characterization of seagrasses conducted by

NOAA Biogeography in St. John and northeast St. Croix, the only other known seagrass monitoring project was that conducted by NPS in St. John. In addition, [Kendall et al. \(2004\)](#) have demonstrated the utility of using aerial photography to map and quantify the spatial changes in seagrass bed distribution around Buck Island, St. Croix over several years (1971 – 1999).

Several spatial gaps in monitoring for macro-invertebrates were identified from unevenly distributed effort among islands and management units. For example, monitoring for conch has occurred on all three islands of the U.S. Virgin Islands, with St. John having the most spatially extensive coverage (see conch figure on page 12), but for St. Thomas however, only three of ten conch monitoring sites occurred along the northern coast of the island. In St. Croix, conch were monitored along the eastern portion of the island east of Christiansted including East End Marine Park and the offshore Buck Island Coral Reef National Monument. Along the south coast, conch monitoring extends from Point Udal westward past Bettys Hope Village towards Long Point Bay. There are no conch monitoring sites along the west coast, in waters around Frederiksted, or in the Sandy Point National Wildlife refuge in the southwest quadrant of St. Croix. Interestingly, the southwest quadrant of St. Croix offshore of Long Point Bay comprises a mosaic of hardbottom and softbottom habitats that could be supporting conch populations. Extensive and spatially-explicit monitoring programs for lobster populations were only identified in the northeast quadrant of St. Croix in and around the Buck Island Coral Reef National Monument. No lobster monitoring occurs in St. John or St. Thomas.

Water quality variables

Water quality variables have been well monitored throughout the U.S Virgin Islands, with the location of monitoring sites fairly equitably distributed among islands and management units. The water quality monitoring focused primarily on popular bathing areas for monitoring risks to human health rather than coral reef ecosystem health. Except for offshore keys, no noticeable spatial gaps are obvious based on the monitoring information compiled in this report. In fact, water quality variables seem to be the only ecosystem metric for which empirical data have been compiled for the Territorial APCs in St. Thomas.

6.2 Temporal Coverage

St. Croix

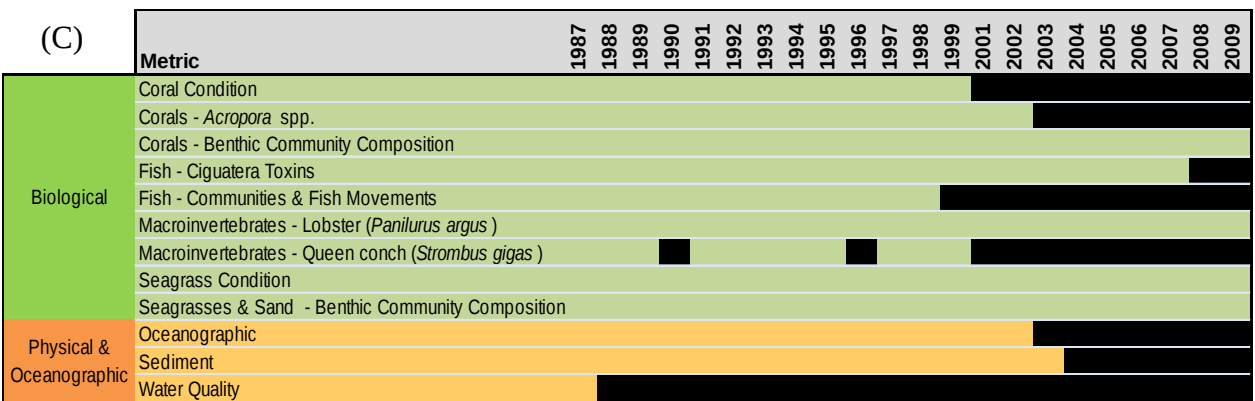
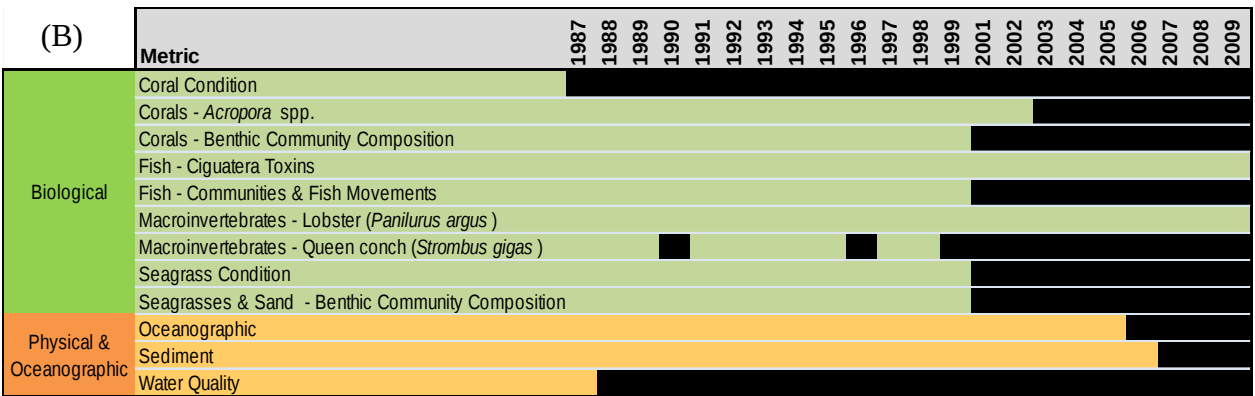
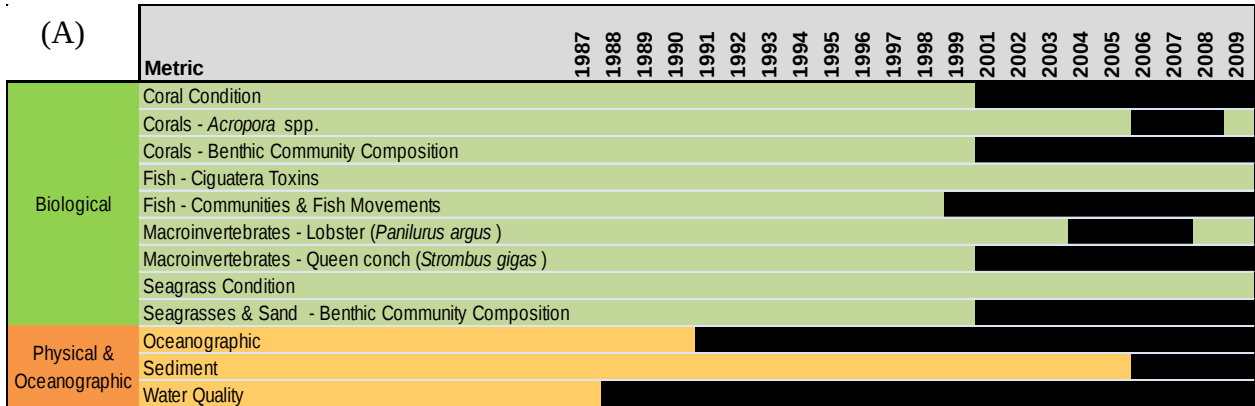
Time series plots of monitoring projects revealed few temporal gaps in the annual monitoring for St. Croix. Several biological variables were consistently monitored annually since 2001, with several projects still ongoing as of 2009. The longest time series were for water quality monitoring which began in 1987. Targeted monitoring efforts for *Acropora* spp. and spiny lobster were fairly brief and lasted only three to five years. See Chart 11a.

St. John

As in St. Croix, time series plots of monitoring projects in St. John revealed few temporal gaps in annual assessments of ecosystem components. Several biological variables have been consistently monitored annually since 2001, with several projects still ongoing as of 2009. The longest times series were for water quality and coral condition monitoring, both of which began in 1987 and for fish at permanent sites since 1988. Targeted monitoring and surveillance of *Acropora* spp. began in 2003 and were ongoing as of 2009. Prior to 2001, Queen conch monitoring was fairly sporadic with a few targeted surveys being conducted by the Virgin Islands Fish and Wildlife Service in 1990 and 1996. However, these surveys used survey techniques similar to those used in earlier surveys conducted in 1981 and 1985. These earlier surveys are important in that they provide historical baselines for comparison with more recent surveys (Friedlander 1997). See Chart 11b.

St. Thomas

Time series plots of monitoring projects in St. Thomas revealed fewer long-term monitoring activities, with fewer metrics being consistently monitored over time. The longest times series are for water quality, which began in 1987. Targeted monitoring and surveillance of *Acropora* spp. began in 2003 and still was ongoing as of 2009. Prior to 2001, Queen conch monitoring was fairly sporadic with a few targeted surveys being conducted by the Virgin Islands Fish and Wildlife Service in 1990 and 1996. However, these surveys used survey techniques similar to those used in earlier surveys in conducted 1981 and 1985. These earlier surveys are important in that they provide historical baselines for comparison with more recent surveys (Friedlander et al., 1994). See Chart 11c.



Graph 11. Time series plots of surveillance and monitoring projects for (a) St. Croix; (b) St. John and (c) St. Thomas, USVI.

6.3 Parameter Coverage

A wide range of parameters are measured across all surveillance and monitoring projects, with very little duplication of efforts. However, one of the major threats to coral reef ecosystem health are the interacting stressors of land-based sources of pollution including sediment runoff that results in chemical contamination, nutrification and sedimentation leading to impaired coral reef ecosystem health. Although nearshore waters are measured with regard to human health issues, no targeted monitoring with exceedence thresholds existed for monitoring coral reef ecosystem health. Sediment monitoring was localized to specific areas to compare impacted versus less impacted watersheds, rather than being a region wide systematic monitoring program. Post- 2009 monitoring activities and sediment contaminant sampling for monitoring sedimentation in response to watershed restoration work (ARRA – American Recovery and Reinvestment Act) and to determine the status of impacted protected areas (St. Thomas East End Reserve) has since been implemented. Further surveillance and monitoring is required to determine the fate and ecological consequences of land-based sources of pollution in the U.S. Virgin Islands.

Furthermore, monitoring effort has not targeted finfish, conch or lobster fisheries and areas that are preferentially fished to assess impacts and monitor population status and trends. Some boat-based observations of sport fishing catches have occurred but these data are not included here since our focus was on in water surveys. Similarly, few studies have systematically quantified human uses of the marine environment across space and over time.

Newly emerging concerns based on predicted environmental changes, including some new threats to ecosystems, are not well covered in the 1990 to 2009 activities. For example, ocean acidification is now recognized as an emerging long term threat to coral reef ecosystems. Bleaching caused by thermal stress is also predicted to increase in frequency, although bleaching is highly visible so can be detected easily through most standard underwater survey protocols.

Targeted monitoring of species recovery is also rarely stated as an objective and few projects focus on individual keystone species such as spiny sea urchins. Very early settlement life stages are usually not included in underwater biological surveys and little is known about the trends in coral supply, settlement, growth and survival. This could be an important parameter with regard to monitoring recovery of Federally protected coral species such as staghorn and elkhorn coral.

7. Recommendations

In response to the widespread reports of decline in Caribbean coral reef ecosystem health there is now an urgent need to enhance the coordination and integration of multi-agency scientific studies and associated monitoring and mapping efforts. Information gaps exist that impede effective decision-making, particularly across the geographical extent of the region. Where data are available, they are often insufficiently utilized, integrated and communicated to managers and insufficiently acted upon due to a lack of adaptive management processes. A coordinated and integrated scientific approach that supports an adaptive management framework is not only more cost-effective through avoidance of duplication, increased cost sharing and effective study design, but will result in a more holistic and responsive approach to ecosystem management. This is a

high-level strategic priority area for NOAA and USVI DPNR. A monitoring program for the USVI is required to ensure that: (1) sufficient spatial and temporal coverage exists across monitoring programs; (2) appropriate ecological components are being monitored; (3) analyses include multiple levels of biological organization from species to assemblages; (4) interactions or connections between components are considered; and (5) best available data and scientific advice are disseminated to the relevant agencies tasked with resource management of coral reef ecosystems in the United States Virgin Islands (USVI). Furthermore, additional seafloor mapping and characterization are required to provide a spatially comprehensive baseline habitat layer over which to design a comprehensive network of monitoring stations and survey locations capable of representing a range of key habitat types, species locales and areas of interest across the region.

Acknowledgements:

We are grateful to all the staff of the many agencies (Federal and Territorial Government, Universities, NGOs) that provided the metadata on their activities in the USVI.

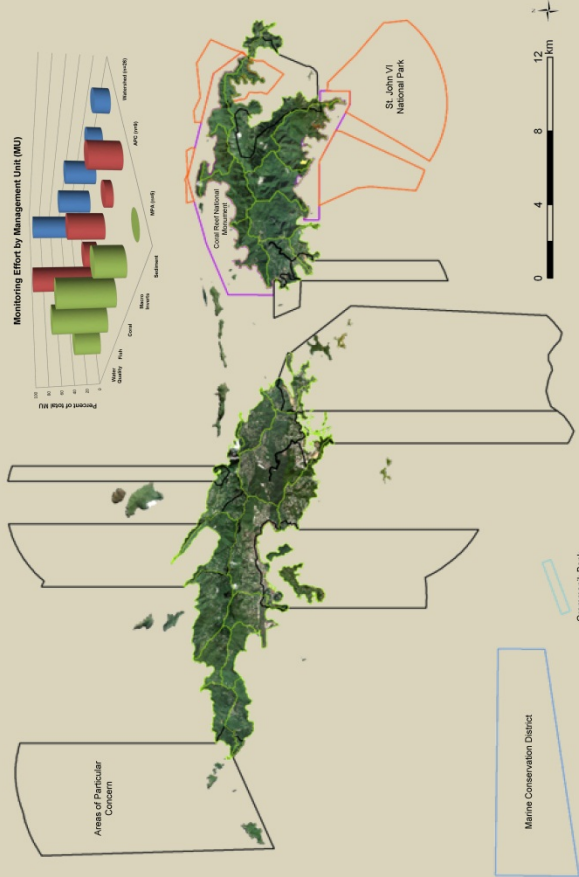
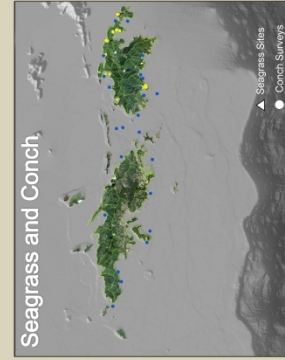
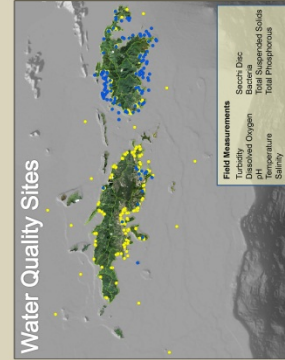
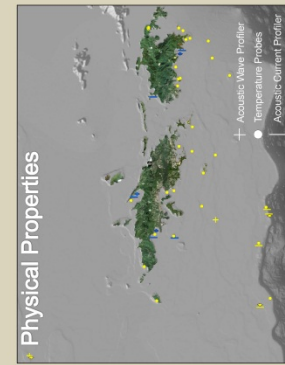
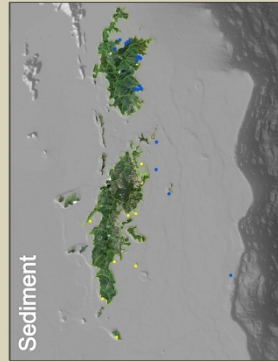
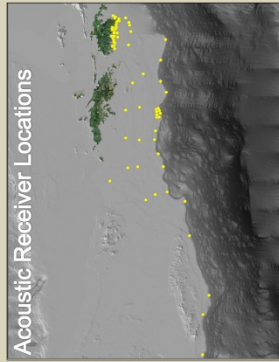
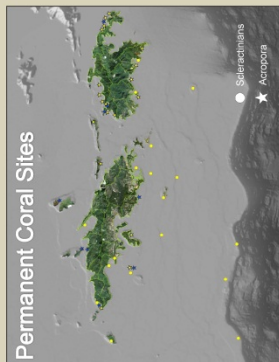
Concluding Note:

We hope that this document is a useful look up guide to help you find new collaborators, identify, share and integrate data sets in novel and useful ways and guide strategic decision making in future monitoring efforts. It is intended that the data also be available in a companion online geoportal that can be periodically updated to include the latest information.

St. Thomas and St. John Marine Monitoring Gap Analysis

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St. Croix Marine Monitoring Gap Analysis

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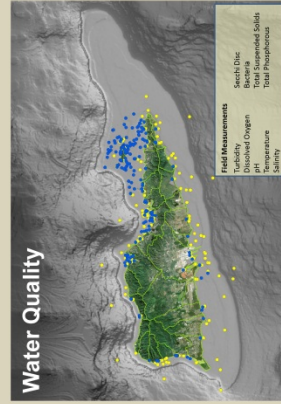
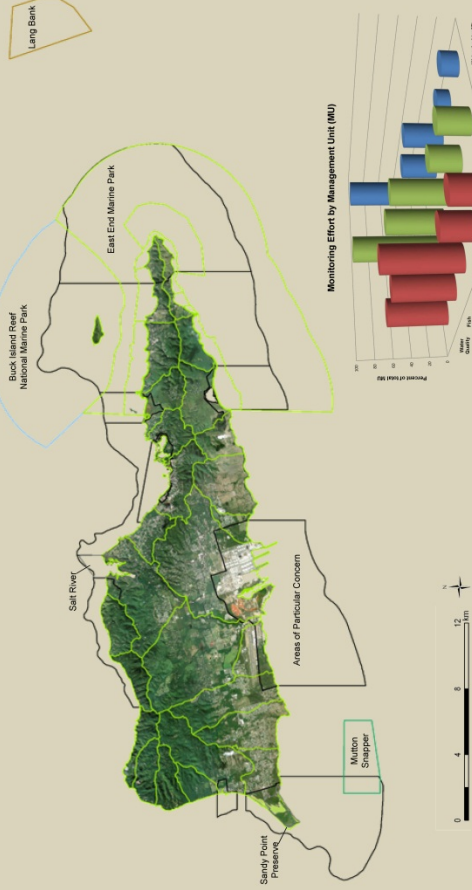
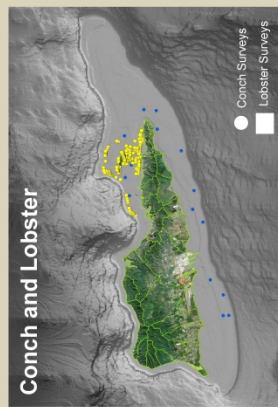
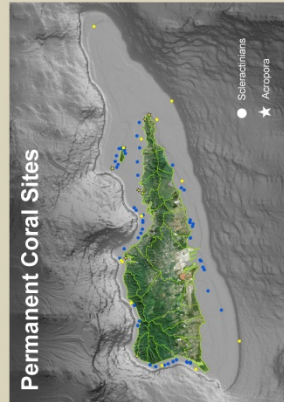


Table 1. Examples of satellite remote sensing data available for monitoring marine environments from space at broad spatial scales.

Product Type	Data Source	Time Frame	Spatial Resolution	Temporal Summary	Units
Pathfinder SST and SST Anomaly (CoRTAD)	NOAA/NESDIS/NODC	1985-2005	4km	daily	°C
SST gradients (CoRTAD)	NOAA/NESDIS/NODC	1985-2005	4km	daily	(°C/12km)
GOES-10/11SST and SST fronts	NESDIS/NODC/STAR	2000-2007	4km	daily	°C
SeaWiFS Ocean Color Turbidity; Remote Sensing Reflectance at 670nm)	NASA	1997-2007	1km	daily	Steradian ⁻¹
Jason-1, Topex/Poseidon, ERS-1/2ENVISAT Sea Surface Height Anomalies	AVISO, SSALTO/DUACS & CNES	1992-2006	1/4° grids	weekly	cm
Jason-1, Topex/Poseidon, ERS-1/2ENVISAT Geostrophic Surface Currents	AVISO, SSALTO/DUACS & CNES	1992-2006	1/3° grids	weekly	cm/s
Land Precipitation Totals and Anomalies	GPCC	1986-2006	1° grids	Monthly	mm
MERIS High Resolution Ocean Color: chlorophyll and water clarity	European Space Agency	2008-	300 m	daily	

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